R/E

RESEARCH & ENGINEERING

FOR RESEARCH & DEVELOPMENT MANAGERS

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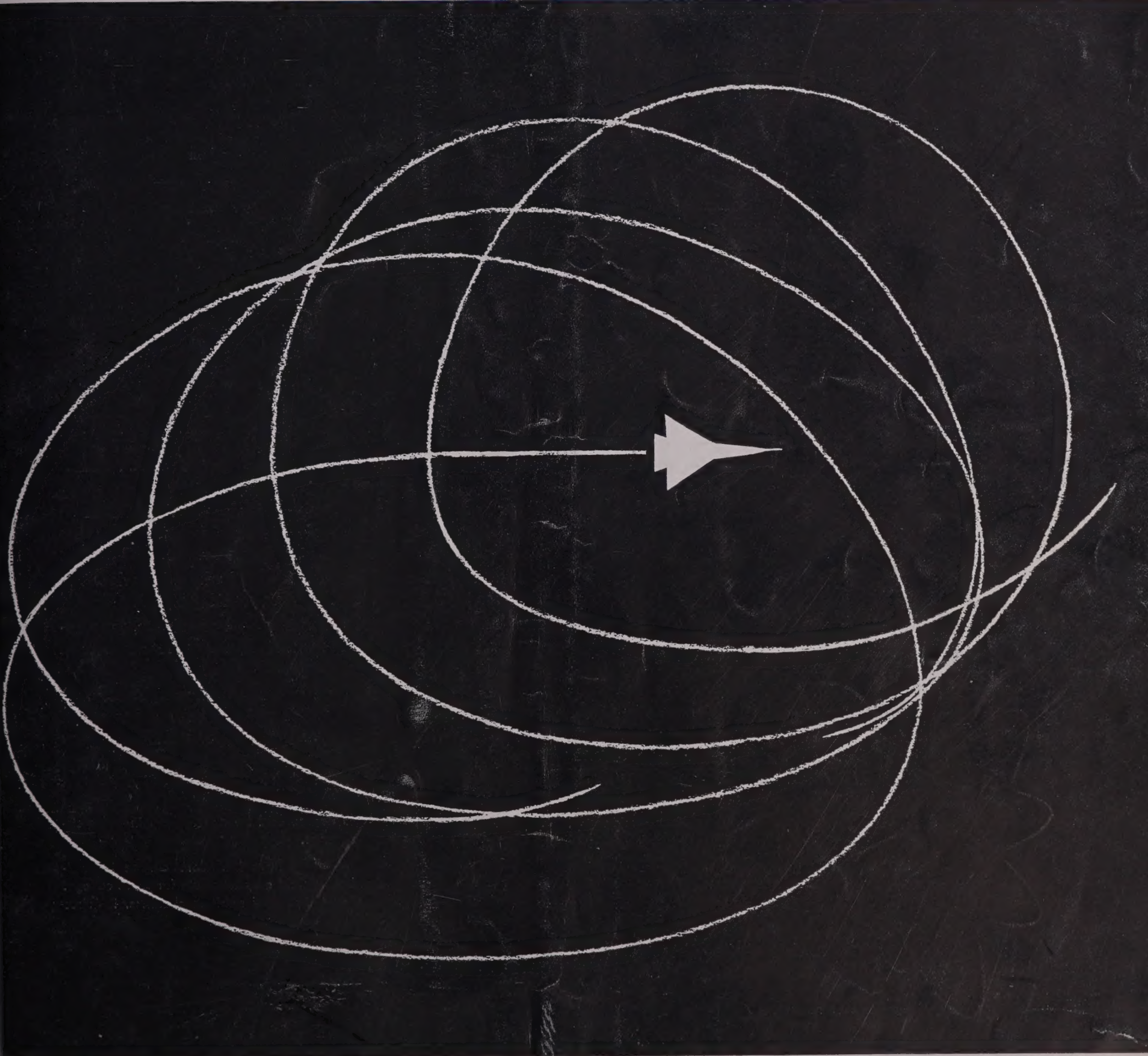
SEPTEMBER 1956

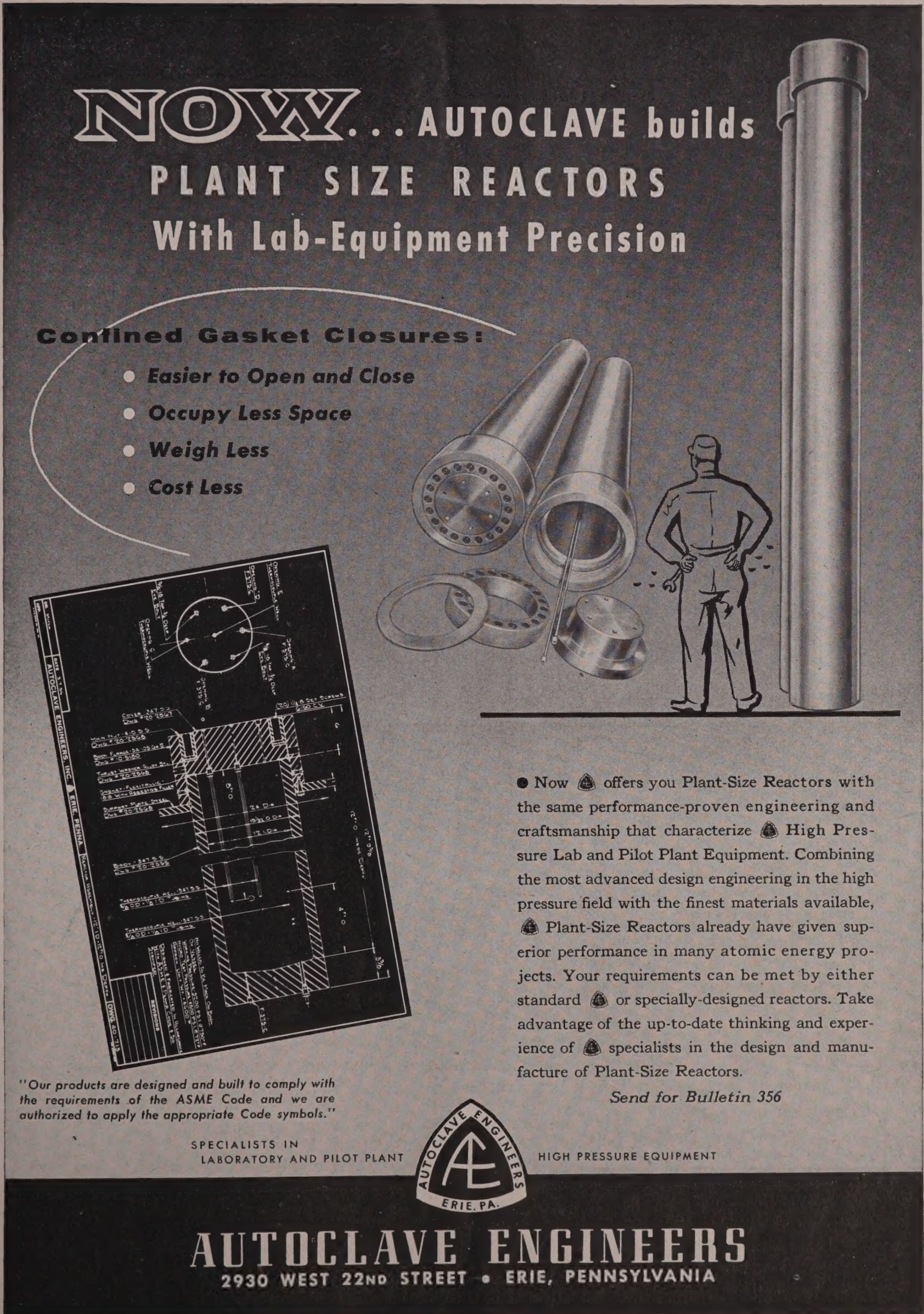


WATER

NEW SOUND BARRIER: Obstacle or Opportunity

AGE OF RESEARCH

GOVERNMENT R & D CONTRACTS: Pitfalls and Procedures



FOR MORE INFORMATION CIRCLE 2 ON PAGE 48

RESEARCH & ENGINEERING

the magazine for research and development managers

SEPTEMBER 1956
VOL. II NO. 9

FEATURES

DEPARTMENTS

RESEARCH & ENGINEERING is circulated to men in charge of industrial research, development and design departments in all branches of industry and in government research installations. Subscription; U. S. A. and Canada. $10.00 annually: other countries, $20.00 annually: Single issue $1.00 when available.
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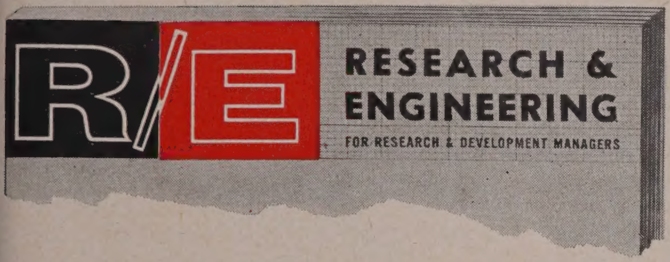
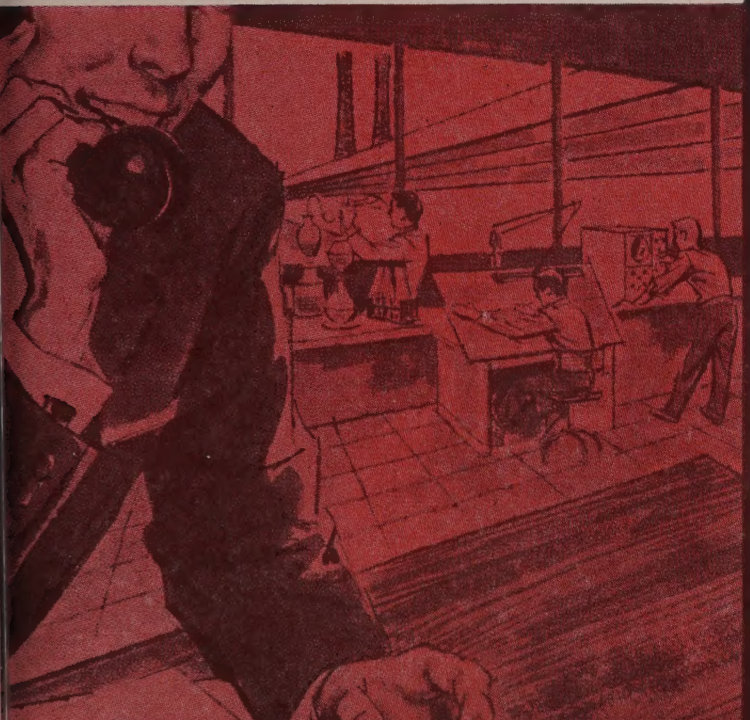
the future of your company depends... n the men who read





You know how important new product and process development has become in your own company — that the very future of your company depends on it. This is just as true in thousands of other companies—and has resulted in the creation of —

a group of men who ten years ago didn't exist!

Who are these men? They are Technical Managers—the engineers, chemists and other technically trained men who, now moved up to the department manager level, are directly responsible to top corporate management for new products and processes.

Why do these men now affect your sales? Companies all over the country are planning changes in plant or products. Their Technical Managers — responsible for the success of these programs — must approve every component part: materials; chemicals; instruments; equipment; finishes; machines; devices—anything that affects the performance of the product or process. And RESEARCH & ENGINEERING is the *only* publication edited solely for the technical managers in charge of these programs—the men who approve specifications and have the authority to specify your particular product or service.

Why do Technical Managers read RESEARCH & ENGINEERING? The Technical Manager now finds his former magazines of insufficient scope for his new responsibilities. No longer merely an electronics engineer, a research chemist or a mechanical designer, he must keep up-to-date on progress in *all* fields of industrial technology. "Management" magazines, dealing mainly with corporate problems, are of little help. Only RESEARCH & ENGINEERING — totally unique in editorial service—meets and solves the Technical Manager's needs and problems, *completely*.

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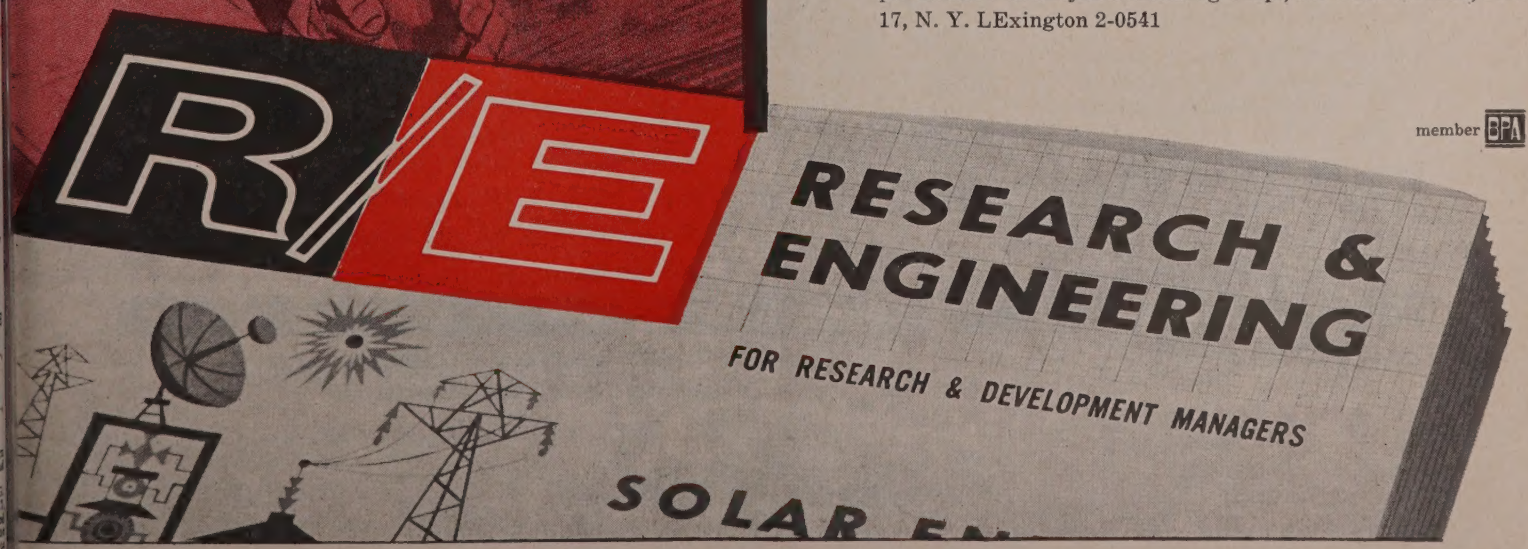
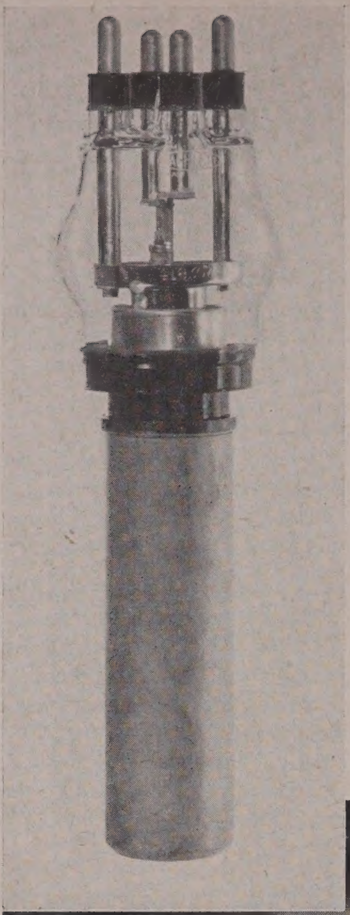


BLISHER'S NOTE: The above advertisement will appear in the October issue of *FORTUNE* magazine—another effort on the part of *RESEARCH ENGINEERING* to bring home to top management the importance of R/D in today's industrial picture. If the corporate management, or vertising people in your company do not regularly read *FORTUNE*, perhaps you would like to mark this page for their attention.



At Wright Aeronautical Division
Curtiss-Wright Corporation

COMPLEX BRAZING

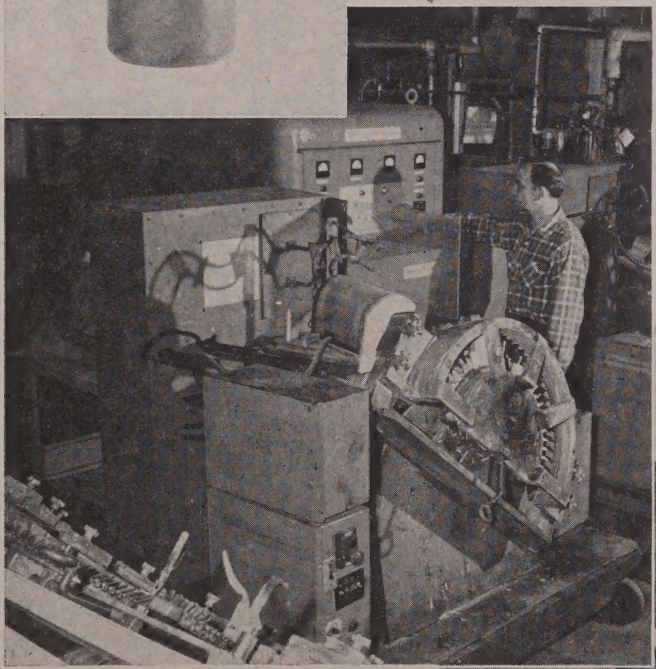
is sure and quick
with R-F Induction Heat
using

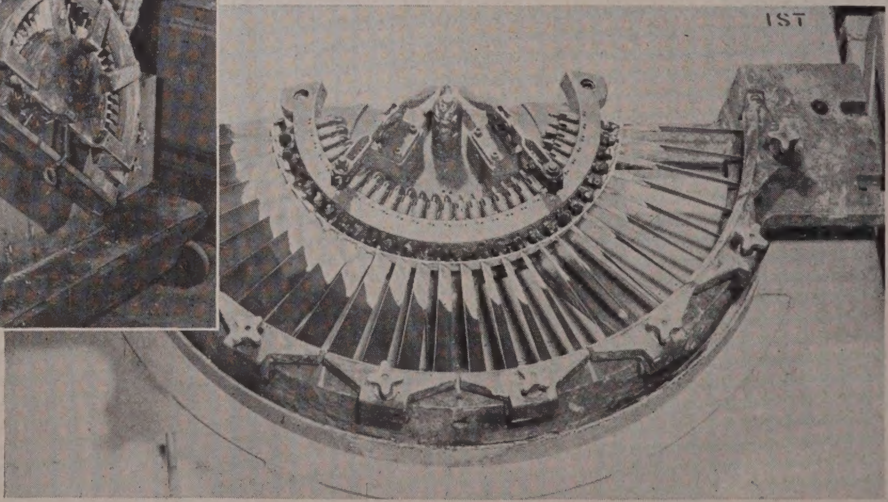
Machlett ML-5668*

INDUSTRIAL OSCILLATOR TRIODES

Each Curtiss-Wright J-65 turbojet engine uses 544 shrouded stator blades. Each blade must be positioned accurately and without physical distortion. Although brazing a single blade to the shroud ring is not difficult, it is quite a feat to perform rapid multi-blade brazing on a sustained production basis. Curtiss-Wright does just this in each of its three induction heating stations, each powered by two Machlett ML-5668 induction heater triodes.

*Machlett induction heater triodes are original equipment in over 75% of the induction heating equipment models now available in the 5kW to 100kW power output range. . . . Proof enough of Machlett electron tube quality and performance!





Top – ML-5668 Induction Heater Triode

Center – One of three induction heating stations used for production brazing of stator assemblies used in Curtiss-Wright's J-65 turbojet engine.

Bottom – Stator assembling jig for Curtiss-Wright's J-65 turbojet engine.

***ML-5668** Original Machlett electron tube design; heavy duty triode replacement for old design, light construction type 892 tube.

MACHLETT — FIRST IN INDUSTRIAL ELECTRON TUBES

MACHLETT LABORATORIES INC.
Springdale, Connecticut

FOR MORE INFORMATION CIRCLE 3 ON PAGE 48

You could fill volumes...

about products that benefit from Vinyl Monomers

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Stronger adhesives and binders for non-woven fabrics. Water and grease resistant coatings for paper, leather and cloth. Vehicles for scrubbable water-base paints. Efficient emulsifying agents, textile sizes and specialty adhesives. Tough, transparent films, protective coatings and safety glass interlays.

Every one of these product improvements can be chalked up to the unusual properties and advantages gained through the use of Vinyl Monomers.

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Salts
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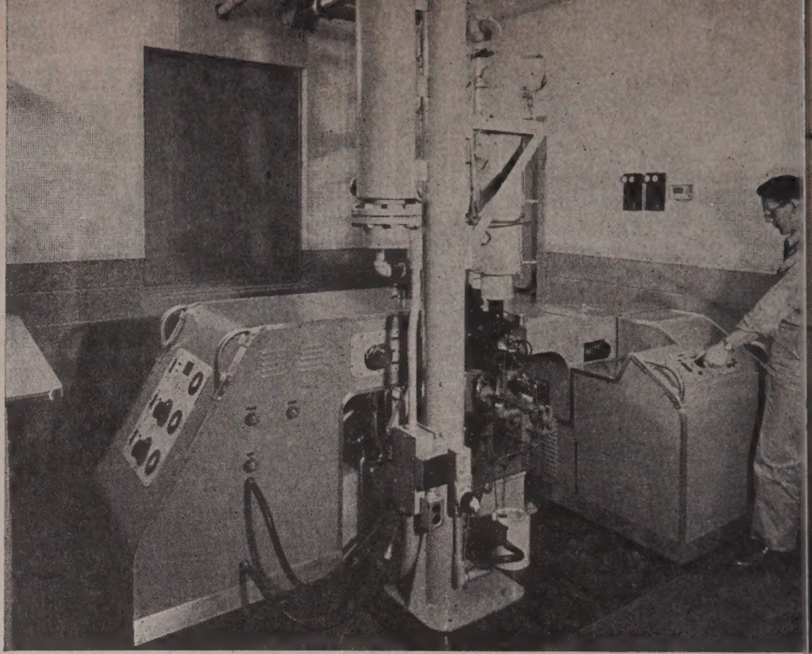
Vinyl Monomers

Celanese CHEMICALS

Agricultural, automotive, aviation, building, electrical, paper, pharmaceutical, plastics, surface coatings, textile.

FOR MORE INFORMATION CIRCLE 6 ON PAGE 48

Du Pont's new engine spectrometer consists of two units: a light source and a recording spectrometer located on opposite sides of the combustion chamber of a CFR single cylinder engine. Special windows in the combustion chamber walls provide an optical path through the combustion chamber. Three individual light sources covering the ultra-violet, visible, and infra-red spectral regions with three different detectors make possible the procurement of absorption and emission spectra for wavelengths of 0.3 to 15 microns. A unique feature of the instrument is a mechanical shutter arrangement that greatly contributes to versatility in the study of rapid processes taking place in the engine. With this arrangement a complete spectra can be obtained at any given stage in the reaction which can be used in the identification of reaction intermediates. Spectral intensity at a pre-selected wavelength can also be followed through the course of the reaction with this shutter arrangement.



Developments

Inside The Combustion Chamber

Using a new spectrometer, the first of its kind, research scientists are now able to study as never before what goes on in the combustion chamber just before knock. Developed for DuPont's Petroleum Laboratory, the apparatus is built around a single cylinder engine. Light is passed through windows in opposite sides of the combustion chamber, in one window and out the opposite. The engine is run in such a way as to cause the reactions leading to "knock" to take place throughout the entire combustion chamber rather than as is normally the case, in only a small portion of it.

As light passes through the mixture in the chamber, some of its energy is absorbed by the chemicals present. Light leaving the engine is converted into electrical impulses for recording on a strip chart. Combustion chamber windows of quartz, rock salt and lithium fluoride make it possible to cover the ultra-violet, visible and infra-red regions. Because each chemical reaction in the chamber varies the amount of light that gets through at different wave-lengths, the spectrometer can make a record, automatically, of changes taking place within the chamber.

The new spectrometer is being used exclusively to determine what causes knock and how tetraethyl lead and other materials react in the fuel to prevent it. From equipment such as this, DuPont researchers hope to find ways of suppressing knock. The spectrometer has begun to yield information on hydrocarbon radicals formed under pressure and their role in knock.

Major emphasis at the present time is directed toward the investigation of the reactions leading to knock. Most information developed in the past concerns the nature of these knock reactions; they have been obtained using indirect experimental techniques such as gas sampling, pressure and radiation measurements, and heat release measurements. These techniques, very helpful in providing inferential evidence on the general nature of hydro-carbo pre-flame reactions leading to knock, are subject to som limitations. This is particularly the case in the identifica tion of the chemical species taking part in the reactions The engine spectrometer overcomes many of these limi tations enabling analysis of the reaction mixture withou disturbing the reaction in any way. Identification an quantitative determination of the many intermediates bein formed and taking part in the reactions is limited only b the sensitivity of the instrument.

Managing an R & D Department

The most important influence on successful managemen of research and development is the company's policies an objectives and its type of business, according to Dr. G. H McIntyre, Vice President and Technical Director for Ferr Corporation. Speaking before the Research and Utilizatio Conference of the American Gas Association, Dr. McIntyr said that the next most important influence consists of th problems of people—the R & D manager's human problems

Effect of Policies and Objectives

Dr. McIntyre said that a clear understanding should exis between management and the R & D administrator and hi staff as to company policies relating to growth, areas o interest, types of products already in production and con templated, and finances.

If the company elects to grow mostly through its own research efforts, R & D emphasis will be on those types o projects leading to new products and processes. If company policy is one of growth through acquisition of already established business, R & D will be directed more toward improvement of existing products and processes.

As an example of how company policies influence a R & D program, Dr. McIntyre cited Ferro's plan of man-

FOR MORE INFORMATION CIRCLE 5 ON PAGE 48

agement decentralization. Each division and subsidiary manager is fully responsible for his own production, sales, and R & D activities. He is responsible to corporate management for the success of his organization's activities under broad corporate policies. Each manager has his own R &D staff. Since these groups are close to customer and production problems, they become more expert in product and process development. Another relatively small group of technical experts is located at company headquarters under the supervision of the vice-president and technical director.

The goals of the R & D program for this latter group differ materially from those of a specific subsidiary's research staff. The corporate R & D organization does long-range research in more advanced areas of product and process development; they also act as technical and scientific consultants to the entire company. Contract research and technical assignments are accepted from the various divisional and subsidiary managers.

Selecting Specific R & D Programs

In selecting a specific R & D program needed to meet company objectives, Dr. McIntyre said that a company must consider the requirements to support existing business and to develop new business. These categories of effort include: (1) improvement of products; (2) improvement of processes; (3) new products; (4) new processes; and (5) new applications.

One prominent director of research reported that one of his top research men had the strong feeling his management wanted completely new, striking products—such as a new nylon—from research. This research director assured his researcher that although his company certainly would not pass up any such high-profit development, his main chance of success was closely associated with obtaining greater profits through research from products and facilities the company already had.

R & D's Human Problems

Dr. Elliott Janney, a consulting psychologist, recently conducted a survey of 63 R & D administrators as to their reactions about themselves and their roles. Most of the replies indicated the basic problems of research administration are the same as the basic administration problems of sales, manufacturing and finance with some exceptions:

"Under most circumstances research people need much greater freedom to operate than do most employees in other departments."

"The more formal education a person has, the more likely he is to stay in research than to go into management."

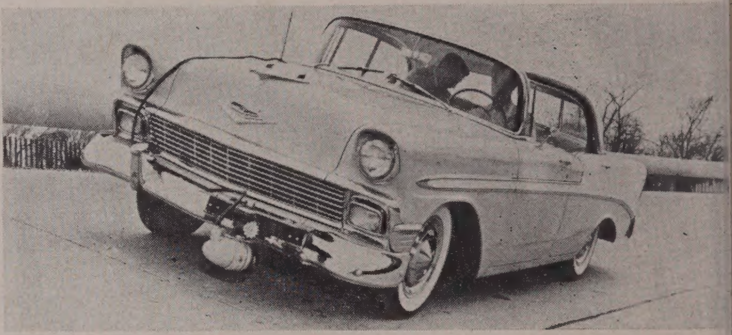
"The worst failures a research administrator can make are: (1) Failing to keep the research function and program sold to other department heads and failure to influence top management to keep it sold to the Board of Directors; (2) competing with one's subordinates for the limelight—failure to know how and when to give recognition to subordinates; (3) failure to develop a nose for the profit potential."

Much is being written on the subject of creativity and how best to stimulate and develop this valuable asset in R & D personnel, Dr. McIntyre said. One approach at Ferro is a President's Idea Committee. This group is composed of the vice-presidents of sales, engineering, manufacturing and research, major department heads, patent and key research people. Company policies and objectives are discussed and an atmosphere for creative thinking is fostered.

Budgets in R & D Administration

Budgets have an important place in research and develo- ment administration. Dr. McIntyre said it is evident th results from research will not be forthcoming simp through the expenditure of large sums of money. Caref budgeting of manpower and costs should be made for eve project. Often, budgets are related to gross sales or prof but the best practice is to consider each project or proble on its own merits and base the budget on the total ma power to be supported. Engineers, he said, cannot be hir and fired indiscriminately. Likewise, research must be su ported through a willingness of management to transla R & D results into capital investments required to co mercialize the new product or process. The decision f required capital investment should come very early in a specific R & D program.

Scanning TV Progress



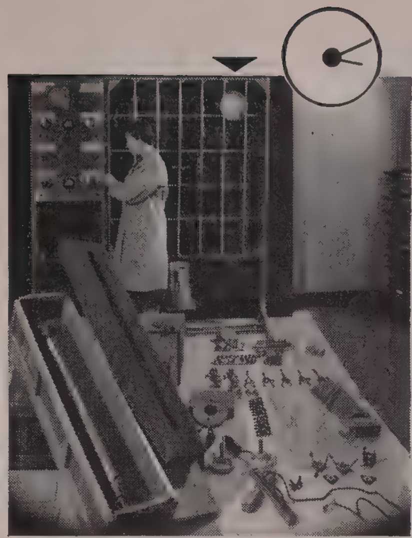
Seated in the back seat of this speeding car, an engineer observes the action of its suspension system by TV. Closed circuit runs from the bomb-shaped General Precision Laboratories' camera, bolted on the bumper, to a 14" monitor on the seat. The picture can also be transmittted to the GM Technical Center nearby.

Although new applications of closed-circuit TV appe in the news every day, this equipment is due for ev greater use in the near future. According to RCA's D Vladimir K. Zworykin, closed-circuit will eventually be common sight in the home and on the farm. Dr. Zworyk feels that closed-circuit TV is at the verge of an expansi comparable to that of the early days of broadcast T Housewives will observe their children in the playroom a farmers the animals in the barn by means of TV.

Live TV from the United States as far south as Venezue is entirely possible, according to DuMont Laboratories' D Allen B. Du Mont, who has just surveyed TV in the Cari bean and South America. To reach Venezuela, "forwa scatter" facilities between Florida and Cuba would be use The blank spot at the present time is the island of Hait "It is in the realm of probability that in a few years li coverage of the World Series will be carried in many Lat American countries," said Dr. Du Mont.

Pioneers in Precision

This summer Miniature Precision Bearings, Inc., open up the first U.S. plant designed and built for the sole pu pose of researching, developing and producing precisi ball bearings in the miniature range—up to three-eighths an inch OD. Although these bearings appear to be no mo than tiny replicas of more common larger ball bearing design engineers face more difficult problems in applyi



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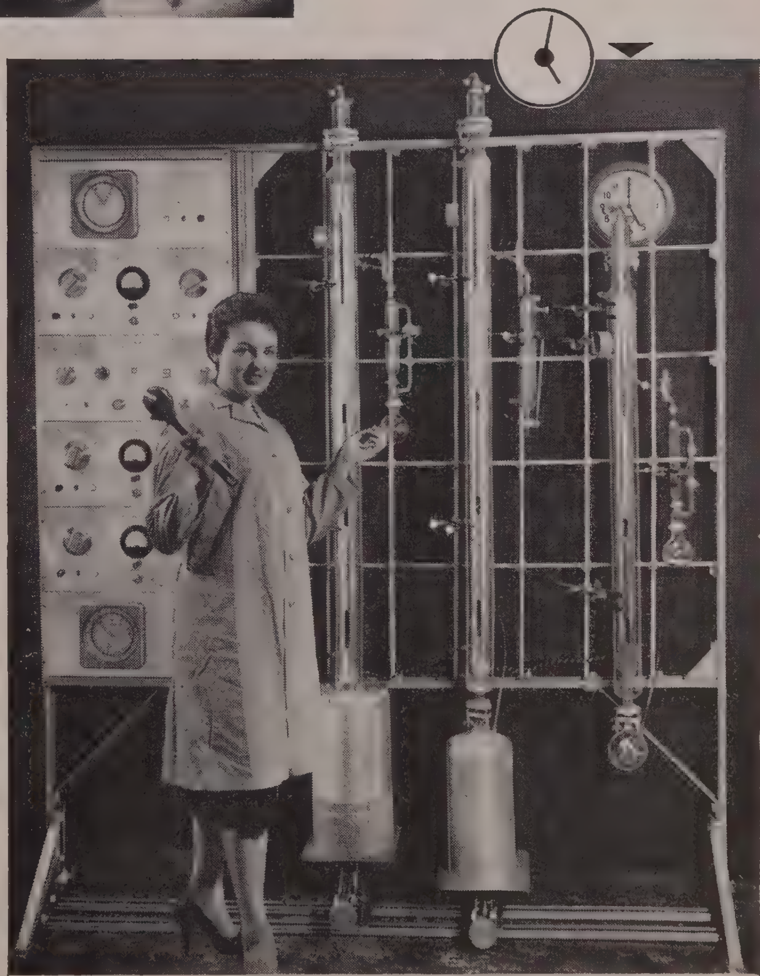

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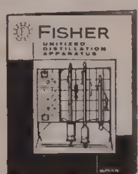
**Overnight shipment from all Fisher plants indicated below.*



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FOR MORE INFORMATION CIRCLE 4 ON PAGE 48

them for optimum performance because of extreme environmental conditions of operation, minute physical dimensions, infinitesimal torques measured in milligrams—millimeters, and the continuing trend in miniaturization.

About sixty percent of the company's bearings are made from 440c stainless steel and about forty percent made from 52100 chrome-carbon steel an extremely small percentage is made from berylium copper heated to Rc45. Current research efforts are being directed towards developing miniature bearings from tool steels and ceramics for high temperature applications. In most current high temperature applications the lubricant rather than the bearing tends to fail and for this reason, the company hopes to develop a miniature bearing for high temperature, requiring no lubrication whatsoever.

Because of the relatively small size of the entire miniature ball bearing industry, most companies have the problem of developing their own test equipment for both research and development work and production. Miniature Precision Bearings is currently working on production torque testers, noise testers and special gages for improvements in bearing production. Other special problems are usually farmed out to consulting groups; currently they are working with Arthur D. Little on a method for making an extremely clean grease for miniature bearing application.

Management's Philosophy

The Precision Park plant in Keene, New Hampshire is a product of MPB's management philosophy of group planning with decentralization of responsibility and authority. Four separate engineering groups report directly to the Vice President in charge of manufacturing. Under the direction of the chief engineer, the design and application group handle the responsibility for the design of standard and special bearings and for field application service to miniature bearing users. Their drafting department works as a part of this group. Their mechanical development section is responsible for the improvement of manufacturing processes and equipment while the gaging section maintains the primary gaging equipment and develops special gages and gaging methods for further manufacturing and improvements. The research and development section restricts itself to the constant improvement of the product itself.

MPB feels that creative thinking is as important as actual experimentation and for that reason provides office space and privacy for its laboratory engineers. These "thought–cubicles" are designed to encourage the application of brain power as well as hardware to the solution of development problems. The company also makes a definite concerted effort to supply sufficient technical and secretarial assistance to free their engineers from routine details.

Whither Miniature Bearings?

Pressures of reduced space and greater precision resulting from the increased complexity and accuracy of electromechanical instruments and control systems are creating a continuing demand for smaller, more precise miniature bearings. Electrical errors in these complicated devices can usually be balanced out but mechanical and dimensional errors cannot. As a result, non-electrical errors, the limiting factors in performance must be held to a minimum. The ultimate goal is a miniature bearing with zero internal friction and zero looseness—no mass shift with no friction. Although an impossible mechanical condition to achieve, it is a goal MPB is attempting to approach asymptotically.

FOR MORE INFORMATION CIRCLE 7 ON PAGE 48

AEC Poses Problem for Chemists: Find Peaceful Use for Plutonium

At the moment, the only known use for plutonium is in atomic weapons; no country has yet developed the technology of burning plutonium, normally manufactured by neutrons interacting with ordinary uranium-238. If all the electricity produced in this country—about 70 million kilowatt years—comes from atomic power, we would be producing about 30,000 kilograms of plutonium-239 as a byproduct, a rather large amount of poisonous and commercially useless material.

The possibility of utilizing plutonium in atomic power piles exists; however, the necessity of doing so is not so obvious. Power piles which do not use highly enriched uranium will generate a great deal of plutonium.

Atomic Energy Commissioner Willard F. Libby warned the American Chemical Society that the problem of what to do with plutonium is a serious one. "Suppose," he said, "that atomic power was segregated from weapons activity as being a peaceful use. Then we would have to say that plutonium generated from reactors was not to be used for atomic weapons. What would then be its value? Obviously, near zero unless we knew how to burn it for power. At the moment we do not, and so the chemist's role in atomic power would become a most vital one in this case, for it is the chemist who will have to tell us how to handle the plutonium in view of its extremely poisonous nature.

Commissioner Libby envisaged that the plutonium made by atomic power piles could be taken into the weapon stock pile to such an extent that one would never need to burn it for atomic power. He calculated that roughly speaking, a kilowatt for one year amounts to one gram of uranium–235 or plutonium–235 annually will produce roughly 29 tons of plutonium as a by-product. Thus, if atomic power is successful and uses uranium of modest enrichment, enormous quantities of plutonium will be generated, exceeding the market in the weapons stockpile requirement. Thus the problem remains, in any case, and becomes a high priority problem for chemists who will have to study how to solve problems involved in using this plutonium for atomic power.

Other Problems

Commissioner Libby posed other problems for chemists. The AEC has asked industry to get into the business of making uranium tetrafluoride and uranium hexafluoride. Proposals for deliveries totalling 5,000 tons per year of U_3O_8, equivalent of these two salts, are desired as of October 1, 1956. To many chemists 15 tons per day may seem like a small operation, but the AEC is speaking of very high

purity material equivalent to pharmaceutical standards at the least.

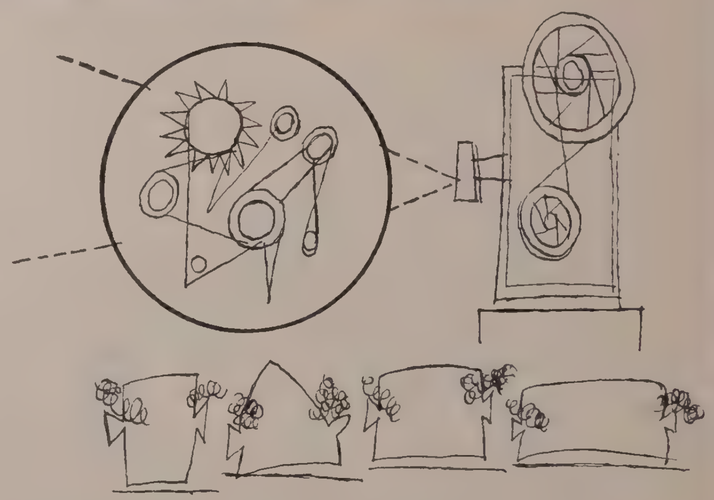
Irradiated thorium blankets must be processed for uranium–233 and plutonium fuel elements must be developed, and their processing mastered. A very considerable job according to Commissioner Libby, remains for the chemist in the methods of manufacturing plutonium fuel elements and processing them after the irradiations are completed. All manner of alloys must be tested and various devices for the prevention of the escape of plutonium in the case of accidents incorporated.

Commissioner Libby also urged that chemists throughout the country join in a broad program on the investigation of the chemistry of high temperature systems on an unclassified basis. He suggested that the program be pursued over a period of years with the thought in mind that in the not too distant future it will pay its way by solving some of the very critical problems of atomic power.

Many people have said that atomic power will never be at its cheapest until the best chemical processing is incorporated and utilized to the fullest extent. Homogenous or fluidous reactors of various sorts have been proposed for the very reason that they bring chemical techniques to the fore. Another serious problem for chemists in atomic power is corrosion in the various atomic power reactors under design. The problem centers on the fact that on one hand, we desire a completely non-corrodible fuel element, and on the other hand, the means by which to dissolve this uncorrodible fuel element and process it for a minimum cost. This conflict forces the use of new degrees of freedom such as are involved in high temperature processing, special dissolution methods and the use of alloys with specific coolants which are inert to the dissolving reagent. This problem will really put the chemist to the test.

Commissioner Libby indicated that some progress has been made to date on this problem by using the homogenous reactor principle: avoid heterogeneous fuel elements and the problem of their manufacture and dissolution and in this way avoid the wasteful conflict above. The most immediate and pressing problem for the atomic chemist is the cheap processing of irradiated fuel elements from the many types of heterogeneous reactors now under construction. For immediacy and quick bearing on the cost of atomic power it outranks the other atomic power jobs the chemist has to do.

Stroboscopic X-Ray Camera: New Tool for High Speed Machine Designers



A General Electric-Detroit Arsenal engineering team has combined stroboscopic, X-ray and camera techniques to achieve the feat of making motion pictures of the innards of a running engine.

The new technique, called stroboradiography, could have a significant effect on engineering design. Slow-motion X-ray movies and still pictures of pistons, cams and other moving parts have enabled engineers to analyze, for the first time, complete cycles of engine operation for faulty performance or wear.

The revolutionary process gives designers their first glimpse inside a completed machine operating at normal speed under load conditions. Improved, light-weight designs, and perhaps important basic design changes could result.

The special stroboradiographic equipment was developed by GE for use with its high-energy industrial X-ray betatron, operating at 5 million to 15 million volts. Unlike conventional X-ray equipment, the betatron furnishes the surging radiation pulses—416 per second—that have given engineers this unprecedented "inside" view of any deflections, vibrations or bouncings inside a running machine. Previously, single-shot exposures of moving objects had been made with low-energy equipment, but the quality of the radiographs suffered when the object was made of heavy parts of varying thickness.

THE RARE EARTHS - A NEW FRONTIER

They offer a rich, new field for research and a challenging industrial potential

a report by LINDSAY

In its restless search for knowledge, science has brought us to the threshold of space, our eyes on the infinity of the universe while we are continuing our investigation of the many mysteries that still exist here on our own planet. One of the richest, most exciting of these virtually unexplored realms lies in that little known group of versatile metals—the rare earths.

There are 15 rare earths—atomic numbers 57 through 71—and together they occupy about .012% of the earth's crust. They are remarkably alike in their chemical behavior because of their atomic structure. The main difference lies in the disposition of the three outermost electrons. The difference is always slight; the heavier rare earth atoms have a smaller radii, hence are denser than the lighter ones.

This characteristic makes separation difficult, but it also makes the rare earths ideal subjects for the study of the magnetic properties of materials and to test various theories of physical chemistry and physics. The rare earths may hold the combination that will unlock many of the secrets of nature.

Industry, too, is turning to the rare earths in a search for materials to improve products and processes. And they have found that the rare earths offer enormous potentials. Already many of these metals are being used in a variety of industrial fields.

Rare earth chloride is a combination of the chlorides of cerium, lanthanum, neodymium and praseodymium with smaller amounts of samarium, gadolinium and less common rare earth chlorides. From this material comes misch metal used in lighter flints and as an additive in many grades of steel. Rare earth chloride also serves in the production of chrome, dentifrices, silk, aluminum, fertilizer and catalysts.

Cerium, most common of the rare earths, is widely used, in its oxide form, as a polishing agent for optical and other forms of glass. Cerium hydrate is an ingredient in the production of the special glass used to view highly radioactive operations.

The rare earths have drying properties that can be useful in the production of better paints. And, neodymium and praseodymium have potential value as colorants in the manufacture of ceramics.

The petroleum industry is investigating the use of rare earths as catalysts in their cracking plants. And this unique group of metals shows promise in catalytic polymerization—a problem in the manufacture of many synthetic fibers and plastics.

Thulium, made radioactive, emits X-rays of proper length and strength for diagnostic use. A pea-sized bit of thulium will last a year as the source of rays in a small, portable X-ray unit . . . a device which would be of great value to physicians and hospitals.

Much of the interest in rare earth and thorium chemicals has been sparked by Lindsay scientists. Since the days of the incandescent gas-mantle lamp, in the last years of the 19th Century, Lindsay has worked and pioneered in this field. Expansion has come as researchers at Lindsay and in science and industry have uncovered new uses for the rare earths. Just recently Lindsay has expanded its ion

exchange installation and now has 100 columns in operation at its West Chicago plant for the separation of some of the "rarer" rare earths in commercial quantities and in purities up to 99.99%.

If you think there is even a remote possibility that the rare earths might have significant applications in your industry, you may find it worthwhile to talk with our technical people. The data obtained through our years of research is available to you and we can supply you with rare earths in quantities from a gram to a carload.

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

274 ANN STREET, WEST CHICAGO, ILLINOIS

The new process involves taking thousands of short exposures accurately synchronized with the moving part. Exposure times of 10 to 15 millionths of a second radiograph an engine turning at several thousand revolutions a minute. A synchronizing disc attached to the specimen engine signals the betatron and releases the surge of electrons that make the split-second X-ray exposure. Several thousand repetitions result in a strong image clear enough to be analyzed for operational data.

To obtain slow-motion movies, X-ray "stills" are taken, for example, of various points in the travel of a piston, and the films spliced in sequence to show the complete cycle of the piston.

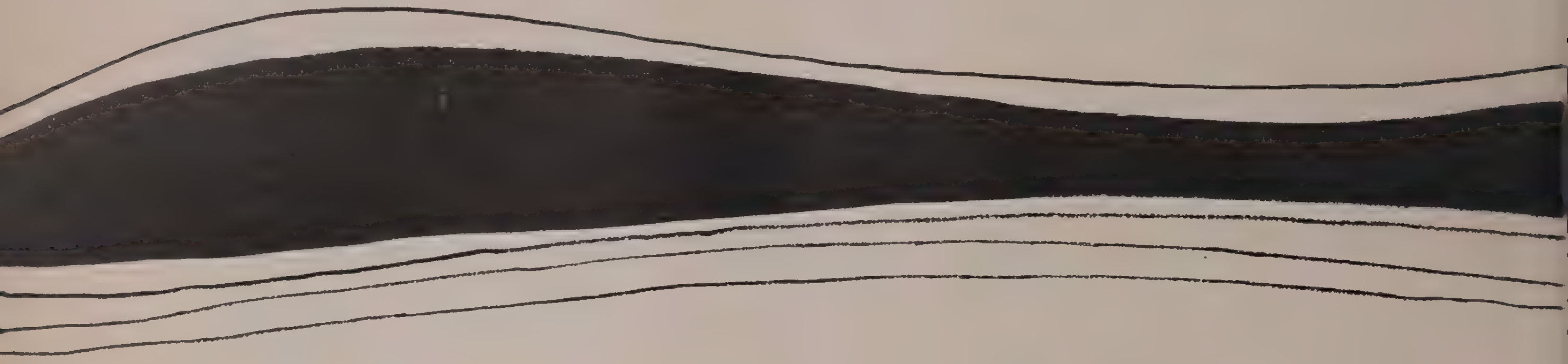
Raymond A. Pulk, chief of the Detroit Arsenal's Materials Laboratory who conceived the idea of adapting the betatron to this concept, explained the strobographic process this way: "Flashing a short X-ray pulse in the same predetermined phase of the engine cycle gives an infinitesimally small action per cycle on the X-ray film, but the superimposition of several thousand of these pulses makes the engine appear to be standing perfectly still when actually it is operating at several thousand revolutions a minute."

Pulk said the technique "will furnish the engineer with a valuable tool to be employed in design and efficiency studies based upon output performance and will definitely contribute to improvement of engine designs."

It is hoped, he added, that any individual shortcomings of a newly designed engine can be corrected by stroboradiographically examining the engine while it is running under load, thus showing up any components that might not be functioning correctly or efficiently.

ALMOST NOTHING: Air collected 75 miles up by an un-manned Aerobee rocket is contained in this steel bottle held by Dr. W. G. Stroud, Army Signal Corps physicist. By analyzing the samples researchers hope to find out if common gases begin separating into layers at 75 miles.

new SOUND barrier:
obstacle and opportunity



MELVIN MANDELL, Associate Editor

Noise generated by increasingly powerful jet and rocket engines has recently been tagged the culprit in aircraft structural failures and equipment malfunction. Identification of the cause has started a flurry of activity in a significant segment of our engineering industries; duplicating noise sources for development testing, analysis of its effects on proprietory products, and ideas for combating it. Worth investigating is the industry that will boom because of the need for sonic test set-ups on the production line. Here's the situation and what will be done about it from those few now in the know.

Noise destroys: Air Force officials are more concerned about the effect of jet and rocket engine noise on airborne components and structures than on humans. Engine noise only bothers people on the ground. Since at least 1952, airframe manufacturers have known that acoustic vibration from jet engines can cause fatigue failures; in 1954 came the first intimation that high noise may be causing some of the mystifying failures in airborne electronic equipment; and a few months ago designers of a turbo-prop engine discovered that standing sound waves overheat turbine blades.

As engines grow more powerful, the noise they produce increases by the third or fourth power of output—compounding the problem. The nation's R & D organizations may soon have to spend millions of dollars collectively to provide sonic facilities in which jet engine noises can be duplicated for testing new equipment and components. Rocket engines produce even more intense noises, but no one expects to be able to duplicate rocket noises. And when atomic aircraft engines become a reality, the sonic test will have to be combined with nuclear radiation.

What is Affected?

That acoustic vibration can affect structural members by causing small but continuous flexure changes has been known for some time. The first time the engines on Boeing's XB-52 were run at full power, structural damage was noticed in only 15 minutes. In 1954 M. B. Levine and F. Mintz of Armour Research Foundation showed that some of the mysterious malfunctions in airborne electronic and electromechanical equipment might actually be caused by high noise. They showed that vacuum tubes, ruggedized military types, exceeded the failure level in output of undesirable microphonics in a noise environment of 130db, some failing at noise levels as low as 120db.

As shown in the oscilloscope photos in Fig. 1, sensitive "null-seeking" relays are also affected by high noise. Accelerometers also showed resonance outputs at different frequencies of high noise. Other delicate electronic and electromechanical equipment are undoubtedly affected by acoustic vibration. Altec-Lansing in Beverly Hills is presently testing accelerometers and gyros for Rocketdyne. The results should be available soon from Dr. John K. Hilliard, Altec's Chief Systems Engineer. Raytheon's Missile Systems Division in Bedford, Mass., is also sonically testing components, but the results are still classified.

Transistors Withstand Noise

Preliminary tests on a small group of Texas Instruments Type *904* silicon transistors performed by Dr. Werner Fricke at Bell Aircraft indicate that they are not damaged by high noise.

Tested in actual operating circuits, the transistors were unaffected by noise levels to 150db. Based on their engineering intuition, a number of engineers had predicted that transistors would resist noise better than tubes because of their smaller mass and more compact construction. Fricke's tests, which are continuing, bear out the predictions. According to Nick De Wolf, Chief Engineer of Transitron Electronic, some transistors may not resist acoustic vibration as well as others. The very small high-frequency transistors now coming on the market in greater numbers are not as rugged as the larger low-frequency devices, and have failed in shake table tests, says De Wolf. However, silicon power rectifiers are very rugged, and they are being specified for aircraft in great numbers. Selenium rectifiers do not resist mechanical vibration well because of their spring-loaded contacts. No data on the ability of these semiconductor rectifiers to resist acoustic vibration are available.

If all transistors prove to be more resistant to high noise than tubes, engineers would have another important reason for pushing their use in airborne devices. At the same time, new tube designs may have increased ability to withstand acoustic vibration. The GE "microminiature" ceramic u-h-f tubes and the new Eitel-McCullough "stacked ceramic" tubes are simply and ruggedly constructed. By their nature, magnetic amplifiers are usually very rugged and may provide important competition to tubes and transistors in high-noise environments.

Just recently engineers at the Allison Division of General Motors discovered that standing sound waves inside the turbine chambers of operating turboprop engines were heating turbine blades to a cherry red condition—a higher temperature than that produced by the combustion gases alone. This problem may have to be solved by cut-and-try methods since a sonic facility that would duplicate the environment inside a turboprop engine would be quite an engineering feat.

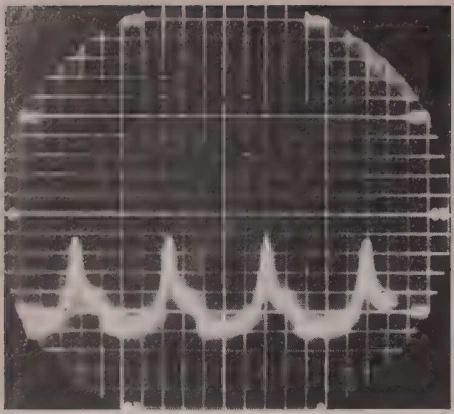
No Correlation with Mechanical Vibration

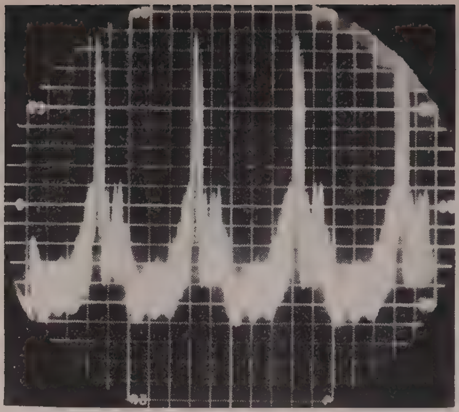
Unfortunately, there is no known or expected correlation between the ability of some part or component to resist mechanical vibration with resistance to acoustic vibration. Vacuum tubes that pass military vibration specs malfunction when exposed to acoustic vibration (and still pass the mechanical test afterwards). If some correlation could ever be made, it would contract the problem for the R & D manager. Mechanical vibration units are common and readily available. They are also much less costly and do not require an expensive containing structure. In addition, most design and development organizations have personnel who know how to operate and maintain shake tables.

What's Being Done About It

To combat the effects of sonic fatigue, airplane manufacturers are making structures near the engines of heavier gage metal with supporting ribs closer together. At Boeing, riveted structures were found to be less resistant to sonic fatigue than bonded materials, so bonding is favored over riveting. As new materials are utilized, they must be tested for sonic fatigue. Perhaps the solution is similar to the one for intense mechanical vibration—give special protection to the most delicate components. One missile design groups the most delicate parts together for added vibration isolating mounting. Similarly, the electronic parts most susceptible to high noise, such as the tubes, could be grouped together and soundproofed. Obviously, such an arrangement would complicate the job of electronic design engineers.

An obvious solution for the airframe designer is to mount delicate parts as far away from and as far in front of the engines as possible. But component manufacturers must expend a lot of money and time to make their airborne devices more resistant to acoustic vibration. Some are already: both RCA and GE are working on the problem, but are not ready to release any





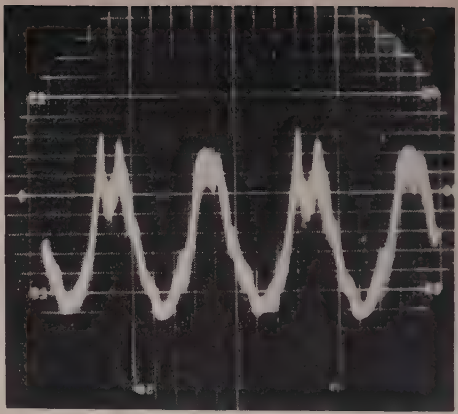


Fig. 1: The effect of high noise on sensitive relays is shown above. On the left and right, the contacts are sufficiently open to cause trouble in most airborne control circuits. The sharp peaks in the middle photograph indicate completely open contacts. All the scope photos were shot at Armour Research Foundation by Levine and Mintz with the relay in 130db sound of 950-, 1100- and 1400cy excitations, respectively, reading from left to right. They have also studied the effect of high noise on ruggedized vacuum tubes.

information. According to R. O. Fehr of GE's General Engineering Laboratory in Schenectady, his company should have something to say on the subject within a year at the most.

For component makers, the final solution may be special lines of "noise-resistant" parts for airborne applications like the "ruggedized" parts now made for certain military and industrial needs. This solution could be backed for tubes by the Defense Department's Advisory Group on Electron Tubes which has just formulated recommendations on mechanical vibration.

Dealing with acoustic vibration is still on a cut-and-try basis. Eventually analytical techniques will be developed. Boeing for one is emphasizing those portions of its sonic fatigue research program ". . . intended to yield analytical methods for use by a designer, to arrive at suitable structures", according to E. Z. Gray, Staff Engineer, Structures.

Overseas high noise is a hot subject. Fundamental research into the nature of acoustic vibration is under way at the University of Southampton, England, under Prof. E. J. Richards. The Bristol Aeroplane Company is studying structural fatigue using two very large loudspeakers as the sound source. A conference dealing with some aspects of the problem will be held in Germany in October. For more information, contact J. Donat, Deutscher Arbeitsring fur Larmbekampfung, Prinz-George-Strasse 77/79, Dusseldorf, Germany. In France some work is in progress at O. N. E. R. A., Paris.

Can't Muffle Acoustic Vibration

Although there is a lot of talk about "sound suppressors" for jet engines to protect people on the ground, these mufflers won't help solve the problem of acoustic vibration. First of all, the military will not use them—even at take-off or low altitudes—because some thrust, even if it only about two percent, is lost and weight sacrificed. Mufflers would be limited to commercial jet aircraft, and on the only ones planned, the Boeing 707 and the Douglas DC-8, acoustic damage is a negligible problem: the engines are way out and back on the slanted wings—far from the very delicate equipment or tail structures. Small civilian jets or jet helicopters, when somebody makes them, may have to cope with the problem.

What Does a Sonic Facility Consist Of?

A sonic facility centers around the object under test. The noise source is directed at it and indicating devices lead away from it. If the object is a structural material, strain gages and displacement gages are usually tied in. Electronic or electromechanical equipment receives operating power and normal input; output must be checked for malfunction or failure. Obviously a number of connections must be made through the walls of the sound chamber. The problem is neatly solved on the Convair "Pipe" by mounting the equipment under test on a wheeled cart like a tea caddy as illustrated in Fig. 8. The cart is rolled into position between the sewer pipe leading from the loudspeaker and the attenuation pad.

Even if you don't attenuate the noise because there are no work spaces or residences nearby to disturb, you must provide some enclosed protection for the engineers and technicians who perform the tests. They can't be in the same room as the sound source wearing just ear-protectors or helmets. In some older installations, phone booths are used, but obviously you can't get much test equipment into a phone booth with an engineer. The Metal Products Division of Koppers Co., Inc., Baltimore, reports that their pre-fab audiometric rooms used to eliminate outside noise for hearing tests are being used to enclose noise chambers or test equipment. But phone booths and audiometric rooms are obvious stop-gaps. To hold all the instruments needed for high noise testing—frequency meters, oscillographs, controls for the noise source, timing devices, strain-gage recorders, a heavy concrete structure with heavy doors is needed. Two layers of concrete slabs with acoustic attenuation material between them surround Boeing's sonic facility. There are two doors consisting of sheets of lead between thick wood; each attenuates 60db. Undoubtedly, most noise sources or reverberation rooms will be enclosed with similar materials.

Providing Sonic Test Facilities

There are a number of ways of providing sonic test facilities.

- The most direct: have someone design and build one for you.
- Design and build your own—if you have or can get the know-how.
- Cooperate with other local manufacturers in procuring a joint facility.
- If you are a subcontractor to an airframe manufacturer, try to borrow his or get him to perform the needed tests on your equipment.
- Rent one from another manufacturer or a testing company.
- Use the one at Wright Air Development Center, if you are an Air Force contractor or subcontractor.

If your organization continually does a great deal of development and design work for aircraft and missiles it would be simplest to buy or build your own facility. Having your own reduces the problems of scheduling, and military and company security. But sonic test facilities cost plenty. Boeing is spending $250,000 on its new one, for example. Designing and building your own facility would most likely cost more than having one of the experienced consultants in the field do it for you, but it's a good way of gaining experience in the art. Then you have a start on getting into the potentially lucrative business of building "off-the-shelf" sonic facilities for others. If there is a sudden rise in the demand for these facilities, the present experts in the field may be so busy you'll *have* to design your own on a crash

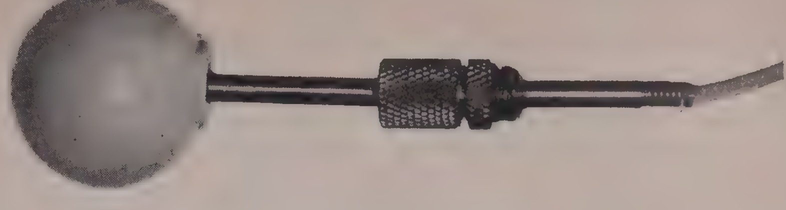


Fig. 2: The noise level produced in a sonic chamber must be accurately measured by high intensity mikes like this Glennite piezoelectric type, linear to 168db.

program basis.

For the smaller outfit with more limited resources, joining other interested laboratories in setting up a cooperative test facility the way West Coast aircraft companies set up the co-op wind tunnel at Cal Tech may be the solution. Although scheduling and security problems are greater, at least cost is lower and a site far from residential areas can be more easily selected.

Three aircraft manufacturers—Douglas, Boeing and Bell—have shared their noise facilities with their subcontractors. According to Paul T. Sauber, Boeing will undoubtedly continue this policy for its new facility to be completed in late 1957. Bell Aircraft, according to Dr. Werner Fricke, has performed high noise tests for its subcontractors in its present facility. Perhaps some of the other airframe manufacturers do or will extend the same privilege. It would be wise for R & D managers to try to include some agreement to use an airframe maker's facilities if they are developing equipment for him. Of course, if you are on the East Coast and your customer is on the West Coast, it may be practical to rent local facilities.

If the demand increases, some of the independent testing organizations might build a sonic test facility for rental—perhaps a mobile job in a trailer truck. For example, H. J. Peranik, Electronics Manager of U. S. Testing Co., New York City, has indicated that his organization is prepared to build a rental facility. Renting a facility would be the ideal solution for R & D organizations that do not deal frequently with the aircraft industry. If you own facility is over-loaded, you might want to rent one. To date, no rental facilities are known to be available.

When the new two-and-one-half-million-dollar sonic facility at Wright Air Development Center is completed, it will be made available to USAF contractors. Better get your request in early. The man to contact is Horace O. Parack, Technical Director and Coordinator, Research and Development Program, Air Force Noise and Vibration Control at WADC. A good description of the facility is in Technical Report 55-154, available from ASTIA Document Service Center, Knott Building, Dayton 2, Ohio.

Whatever the solution to the problem of securing sonic facilities, the need for providing such facilities for designers of aircraft or airborne gear means that large engineering organizations will have even greater advantages over small companies in bidding for and fulfilling R & D contracts for the military. Contracting officers might favor firms possessing sound chambers or even insist that they acquire one before awarding a contract for some airborne instruments. And whatever type of facility will be acquired may soon become obsolete as jet and rocket engines produce louder and louder noise.

What's the Best Sound Source?

There are a number of possible sources of both "white noise" and single-frequency sounds.

- Electromagnetic loudspeakers
- Modulated-air-stream loudspeakers
- Sirens
- Jet streams
- Saluting cannons
- Standing wave tubes
- Whistles
- Actual jet engines

The electromagnetic loudspeaker is the most commonly used source. With the most powerful available loudspeaker, a noise level of 150db can be reached. Doubling the number of loudspeakers only raises the level 3db, so that two produce 153db, four 156db, eight 159db and 16 162db. It is difficult to conceive of a practical geometric arrangement of more than seven loudspeakers, such as the one shown in Fig. 5. And the moving-coil loudspeaker is not very efficient—only about two percent (the electrostatic type is even less efficient).

Dr. Hilliard says that a practical R & D project would be the development of a loudspeaker through which a great deal of sound per square foot of loudspeaker surface could be pushed. Perhaps the modulated-air-stream loudspeaker is the answer, but none is available. Stanford Research is working on this type of loudspeaker and should release results of their study shortly.

Sirens are used on a number of sound chambers. Douglas' new facility at Santa Monica has a siren source expected to develop 3000 acoustical watts at 165 to 170db in a 1′ x 4′ x 4′ rectangular parallelepiped, according to Mr. M. M. Miller, Supervisor, Acoustics Group. Panels up to 4′ x 4′ will be attached to one of 4′ x 4′ sides, with the siren feeding into one 1′ x 4′ side and the air exhausting through the opposite 1′ x 4′ side into an expanding duct lined with fiberglass (effectively a "ρc" load).

Boeing's present facility uses a source like a siren, although they call it a "modulated compressed-air" source. They rejected air-raid sirens when they discovered 165hp were required to produce 145db. In their arrangement, compressed air is driven through a motor-driven chopper valve. The valve consists of twenty 0.4″ holes evenly spaced on the rotor and matched with identical holes in the stator. A thyratron-controlled series motor drives the valve. The difference between the output of a tachometer generator on the motor and an adjustable d-c reference voltage controls the output frequency. A laminated fiberglass exponential horn couples the source to the test panels. Five hundred cubic feet per minute of air through the valve produces a sine wave note of 160db intensity. Raising the flow to 1300cfm produces a 170db triangular wave note.

If the panel is small enough, it can be mounted right inside the horn. The noise level is 183db in the horn right behind the test mike. (For a very complete description of the Boeing facility, read Paul T. Sauber's paper in the *Proceedings of the Second Annual Meeting of the Science Section of the Environ-*

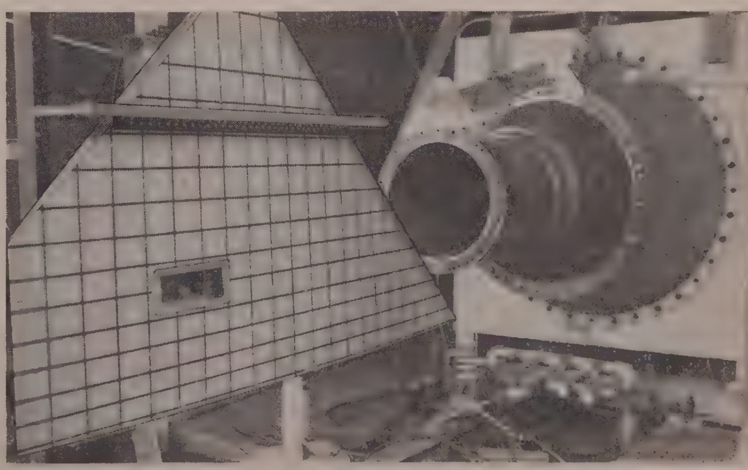


Fig. 3: At first Boeing tested aircraft structures like this stabilizer for their ability to withstand high noise in actual jet engine exhausts.

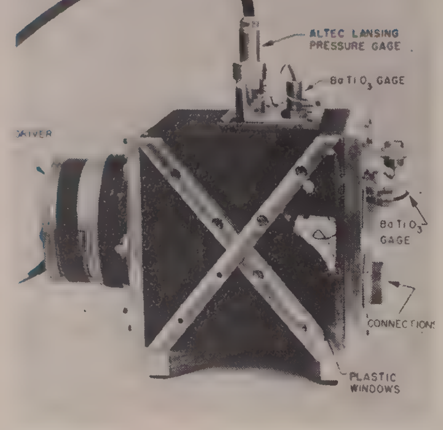


Fig. 4: Only 6" x 6" x 6" in size, this is one of the first sound chambers, built by Armour Research to test components to 150db. A 50w loudspeaker driver is the source.

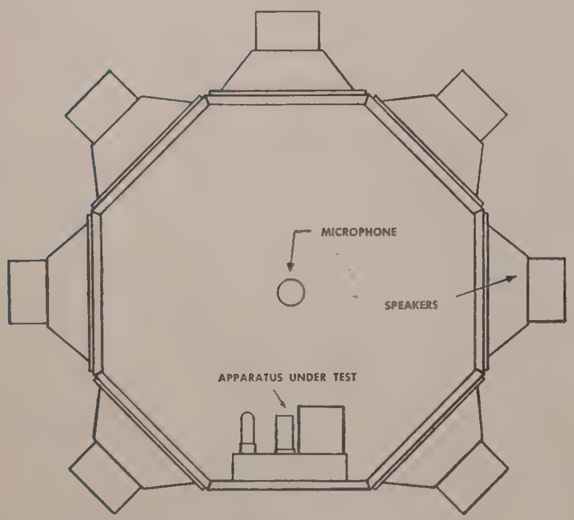


Fig. 5: Seven loudspeakers mounted in this hexagon are about the practical limit that can be used in a sound chamber. (Designed by Hilliard of Altec-Lansing.)

Fig. 6: Small components such as transistors and miniature vacuum tubes could be tested to high noise levels of 180db in this standing wave tube. It is used to calibrate Altec-Lansing microphones.

mental Equipment Institute, available from the Institute, Room 524E, 30 Church St., New York, N. Y.)

Air jet streams are one source at the NACA's Langley Aeronautical Laboratory at Langley Field, Va. The National Advisory Committee for Aeronautics is more concerned with the effects of acoustic vibration on structures than airborne equipment. Levine of Armour Research believes that air jet streams will be the source used to produce the higher noises needed to test structures and equipment for the ever more powerful aircraft of the future. At present, the NACA uses both sirens and air streams as sound sources. The University of Southampton, England, uses air jets.

Using *actual jet engines* as a source of noise is very difficult. When Boeing first encountered serious sonic fatigue on the XB-52, they tested some missile stabilizers in the exhaust stream of a jet engine at their Shuffleton Power Plant Test Center. But running a jet engine long enough to destroy sonically a structure in its exhaust is expensive. Tons of fuel are required and the engine has a limited life. Obviously, electronic equipment could never be tested this way, even if an electronic R & D lab could arrange with an engine manufacturer to run concurrent tests of equipment and engines. Boeing soon went to work on their present sonic faciilty.

Saluting Cannons are used by Bolt, Berenek and Newman, consulting acoustic engineers of Cambridge, Mass., to test the muffling qualities of jet engine tests. The cannon has a frequency spectrum very similar to that of a jet engine. Jordan Baruch of the above firm suggested the cannon as a possible source of noise for acoustic vibration. Firing 10-gage shotgun blanks, the cannons produce 10,000 acoustic watts for an instant. But their use seems very limited and impractical. To accurately observe the effects of acoustic vibration, a steady rather than pulse-type source is needed.

Altec-Lansing makes a *standing-wave tube*, shown in Fig. 6, used to calibrate their high-intensity mikes; levels to 180db are available. Hilliard has suggested their use for testing very small components such as subminiature tubes, transistors, diodes, the smallest relays, and resistors and capacitors. A special mounting would be needed to hold the component in the calibrator with leads running off to its operating circuit and instrumentation.

Whistles could be another sound source. At the recent International Congress on Acoustics in Cambridge, French engineers and scientists described two types of whistles that produce intense ultrasound when compressed air is forced through them. But they also produce a fundamental frequency in the audible range. These whistles are very efficient compared to loudspeakers, but they are essentially fixed-frequency devices. According to Robert L. Rod of Acoustica Associates, a combination of these whistles could be made to simulate the frequency spectrum of a jet engine. When sonic testing reaches the production line and a fixed frequency is specified for a particular component, comparatively inexpensive whistles might become an important source of high noise. Licenses to manufacture the French whistles in this country are now under negotiation.

According to Dr. Hilliard, the sonic facility of the future will utilize a number of sound sources: loudspeakers for duplicating jet noise spectrums up to something over 150db; jet streams or modulated air streams for more intense sounds; sirens for single frequency. The sources could all be located in one room, or in separate sound chambers.

How Big?

A major cost factor in specifying a sound chamber is the interior volume. It isn't too difficult to produce high levels in a small volume. But larger chambers, especially ones large enough to hold the biggest pieces of equipment and full-size structures are very expensive. And the chamber must be considerably larger than the object under test for proper distribution of the sound.

One solution for the designer of complete equipments is to break them down into component parts and test each part separately, duplicating all the inputs, of course. Component designers have a lesser problem. Most airborne tubes, gyros, accelerometers,

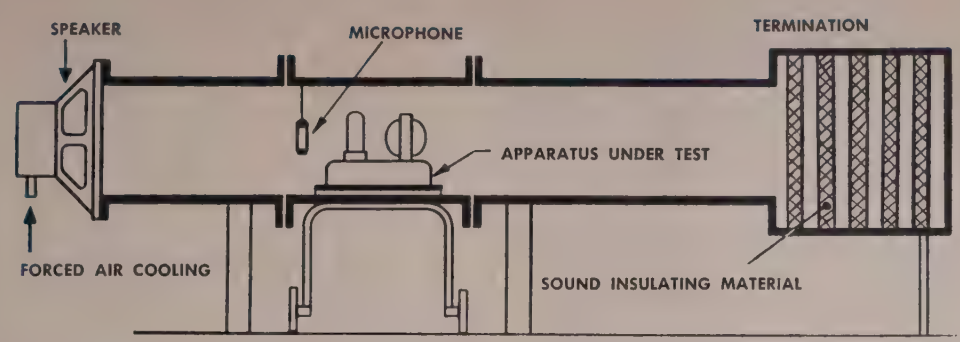


Fig. 8: Sewer pipe is used as the chamber wall in the Convair "Pipe". Apparatus under test is quickly rolled into test position on the cart.

relays and other susceptible parts can be tested in small set-up's.

For the aeronautical engineer, a less expensive solution may be testing scale models of structures and test panels in a smaller chamber. But Boeing has found the extrapolation from scale panels to full size difficult. They claim it is cheaper in the long run to test full-size panels in an expensive sonic chamber. As a result Boeing is building a larger sonic facility.

Test panels up to 5′ x 5′ will be exposed to 190db in the new installation. Cost of the air compressors alone for the modulated-air-stream sound source will run into six figures. Obviously a lot of soundproofing will be required for a relatively quiet instrumentation room nearby. This facility will be finished in '57.

Who Designs Sound Chambers?

Only a small number of organizations and individuals have had any experience in designing sound chambers. Armour Research has submitted a bid to WADC on a new high-intensity facility. They are interested in unusual problems in the field. Bolt, Berenek and Newman, Inc., in Cambridge are well equipped to design sonic facilities. On the West Coast, Hilliard recommends William B. Snow, an engineering consultant located at 1011 Georgina St., Santa Monica, Calif. Although Altec-Lansing has been advising people on this problem and suggesting possible solutions and instrumentation, they do not handle the design of complete facilities. But they might get into the business; they have a head start in a potentially important minor industry. According to Hilliard, manufacture of "off-the-shelf" sound chambers will be a substantial business in two to five years.

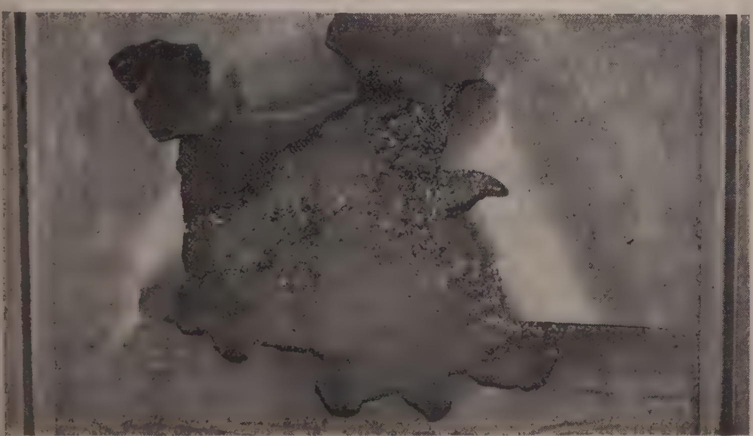


Fig. 7: This honeycomb sandwich metal panel was destroyed by 170db noise in tests at Boeing.

Duplicating Rocket Noise

Only the noises produced by jet engines, now approaching 180db, can be duplicated in sonic facilities. No one hopes to duplicate the extremely intense noises produced by rocket engines. One large New England electronics manufacturer seeking someone to design a large facility to duplicate rocket noise received a bid from an acoustic consultant for over $1,000,000 just for the design *without any guarantee of success.* To reproduce the lower frequencies in a large room, mechanical vibration of one wall of the sound chamber by some reciprocating device was actually under consideration.

Inside the instrumentation compartment of a rocket missile the noise level may be attenuated enough to be duplicated in one of the louder sound chambers. As for the higher noises inside missiles, about the only way to find out if components can stand them is to put them into the missile and shoot it off, according to Hilliard.

Management's Problems

For engineering management, acoustic vibration raises two problems—providing the engineers and technicians to man the sonic facility and teaching your design engineers how to cope with high noise. At Bell Aircraft, a team of one electronic engineer and one technician make up the crew for each sound chamber. Construction of a number of these facilities could place a further strain on our technical manpower resources.

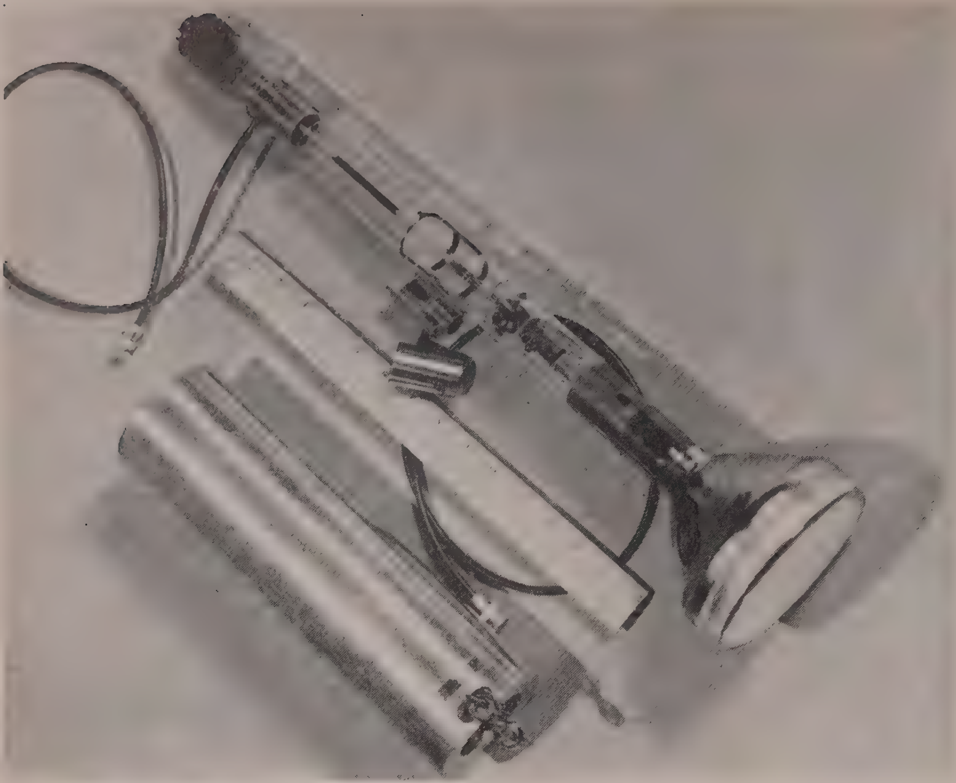
Making engineers aware of the problem of acoustic vibration should be less and less difficult. With all the work on this subject, a number of papers should be presented on acoustic vibration in the next year, barring secrecy restrictions. For example, Dr. Fricke will discuss his work in the field at a meeting of the Rocket Society in Buffalo this month. Altec-Lansing is doing a fine job of educating people on this subject and Dr. Hilliard is travelling about the country advising organizations with problems in duplicating and measuring high noise. Some of the work of Levine and Mintz was published in the AIEE's *Applications and Industry* of January, 1955. (Reprints are available from Armour Research.) To educate its engineers, Boeing has prepared a 33-page report on sonic fatigue for internal distribution.

Performance Standards

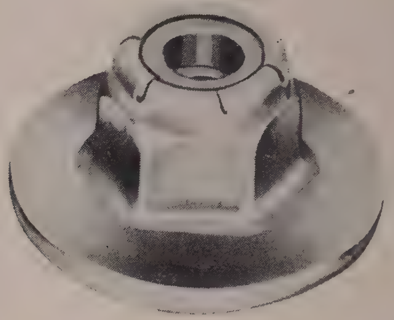
None of the major organizations that set standards—ASA, ASESA, IRE, RETMA or the military—have as yet set standards for resistance to high noise. According to WADC's Parrack, there isn't enough information known about the field yet ". . . to justify an attempt to prepare standard specifications". Undoubtedly standards will be set at some time. Some of the airframe manufacturers such as Convair (Fort Worth) are setting high-noise performance standards for their subcontractors.

Headache or Challenge

Noise will be an increasing problem for the nation's R & D labs. Most money will be spent on eliminating or attenuating noises objectionable to humans, but increasing funds will be needed to combat acoustic vibration. If high noise is a headache to most designers, it could represent a challenge to others for developing sorely needed components, materials, instruments and equipment. The emergence of the problem of acoustic vibration is just another indication that as we advance technologically we create just as many new and vexing problems as we solve. END



COMPONENTS



Simplifies Radar

Most of the essential functions of a microwave receiving set are combined in this tube envelope, eliminating many tubes and components in radar and TV. The "Wamoscope" operates over the 2000 to 4000Mc band. Although this first model has a 5" screen, there is no limit on screen size.

Developer: Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y., in cooperation with Naval Research Laboratory.

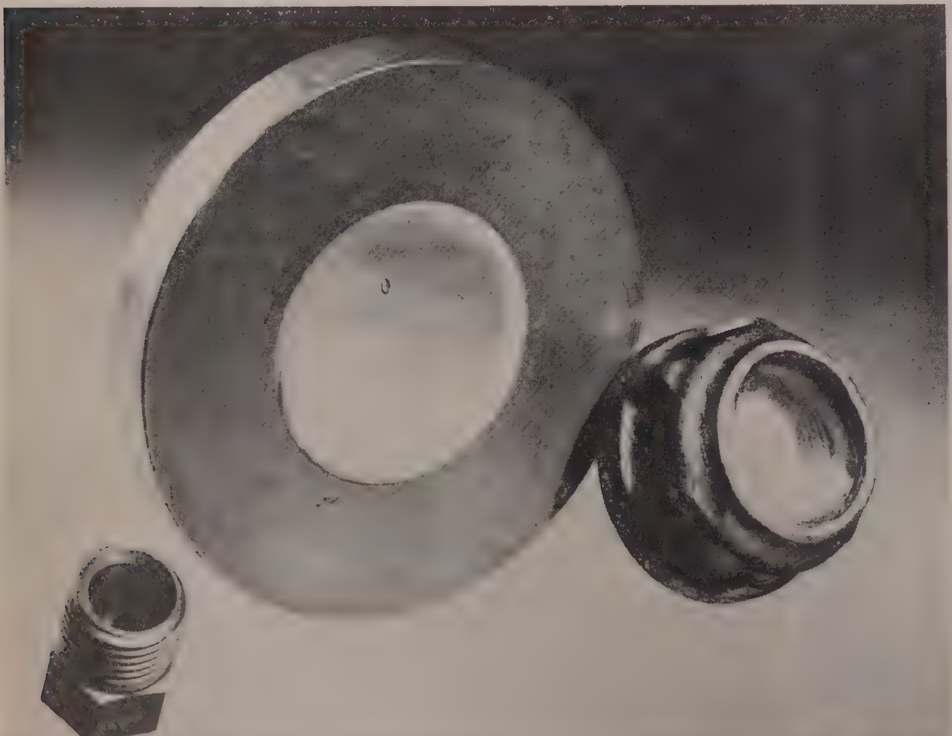
For more data: circle 20 on p. 48.

Nut For Spring Tension

Designed with a large washer-type seat for fastenings involving spring tension, the Type 1994 self-locking nut eliminates the need for individual nuts and special washers in such applications. The base flange against which the spring seats is one inch in diameter.

Developer: Elastic Stop Nut Corp. of America, Union, N. J.

For more data: circle 27 on p. 48.

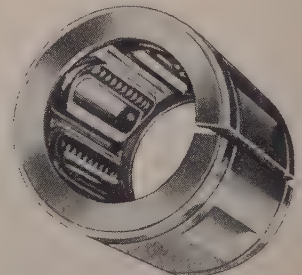


Leakproof Sight Glasses

The chemical industry among others will welcome these new sight glasses in which the glass is hermetically sealed. No gasketing or solders needed. When tested on a helium leak detector at maximum sensitivity, no leaks were detected. One window ⅜" OD and ⅛" thick stands pressures of 5000psi.

Developer: Corning Glass Works, Corning, N. Y.

For more data: circle 21 on p. 48.



Adjustable Bearing

Split longitudinally, these bearings provide line-to-line or slight preload fits when mounted in an adjustable diameter housing. Permits free-running no-play linear motion and compensation for wear that might eventually develop in severe applications.

Developer: Thomson Industries, Inc., Manhasset, N. Y.

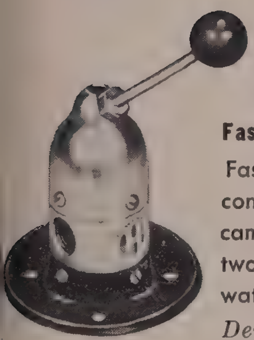
For more data: circle 23

Cradled Light

The all-rubber housing around this lamp protects it against the stock and vibration encountered in aircraft. It is easily installed and replaced and the body can be molded to any configuration.

Developer: The Lighthouse, Inc., 2315 Grand Ave., Los Angeles Calif.

For more data: circle 24



Fast-Acting Valve

Fast cycling of the "Quick Dump" valve can be controlled in seven different ways — solenoid, cam-operated, palm button, finger-tip, foot, and two types with hand lever. For use with air, water, oil or freon to pressures to 125 psi.

Developer: Humphrey Products, General Gas Light Co., Kalamazoo, Mich.

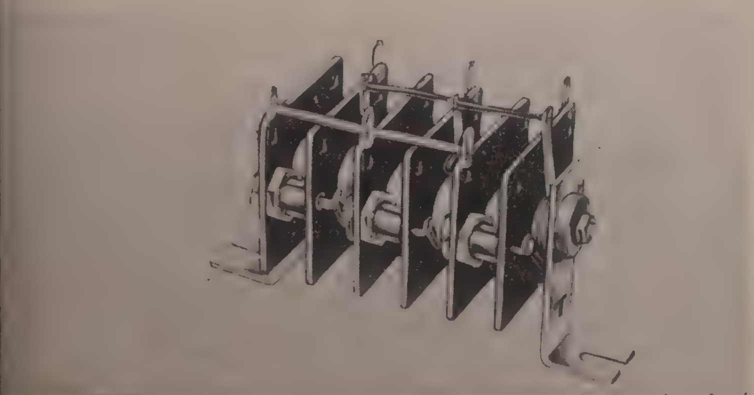
For more data: circle 22 on p. 48.

Distortion-Free Heat Treating

Small precision steel parts can be finish machined before heat treating by a new process without distortion or discoloration. Hardness of any desired degree can be obtained.

Process Developer: Allied Products Div., Hamilton Watch Co., Lancaster, Pa.

For more data: circle 26 on p. 48.

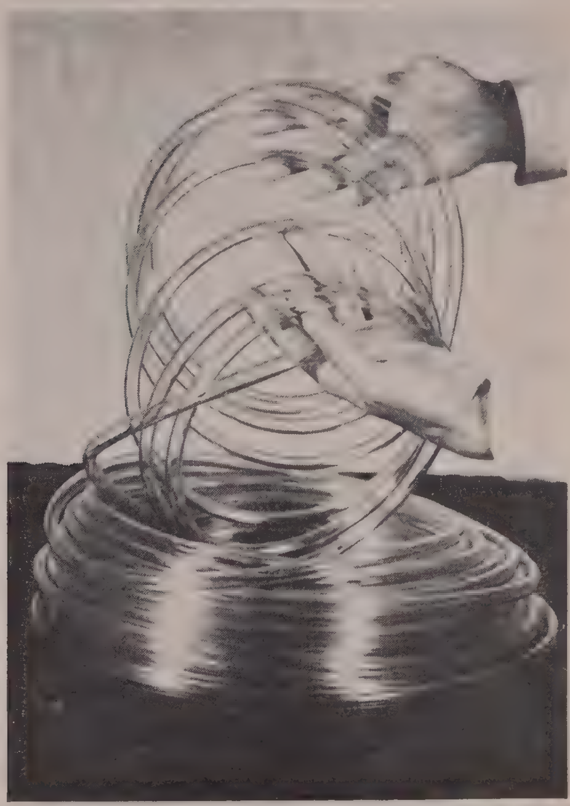


Transparent Tubing

Able to withstand a wide variety of chemicals and reagents, this transparent vinyl or polyethylene tubing is made in a number of inside diameters from ⅛" to 1". It can be steam sterilized.

Developer: American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio

For more data: circle 28 on p. 48.

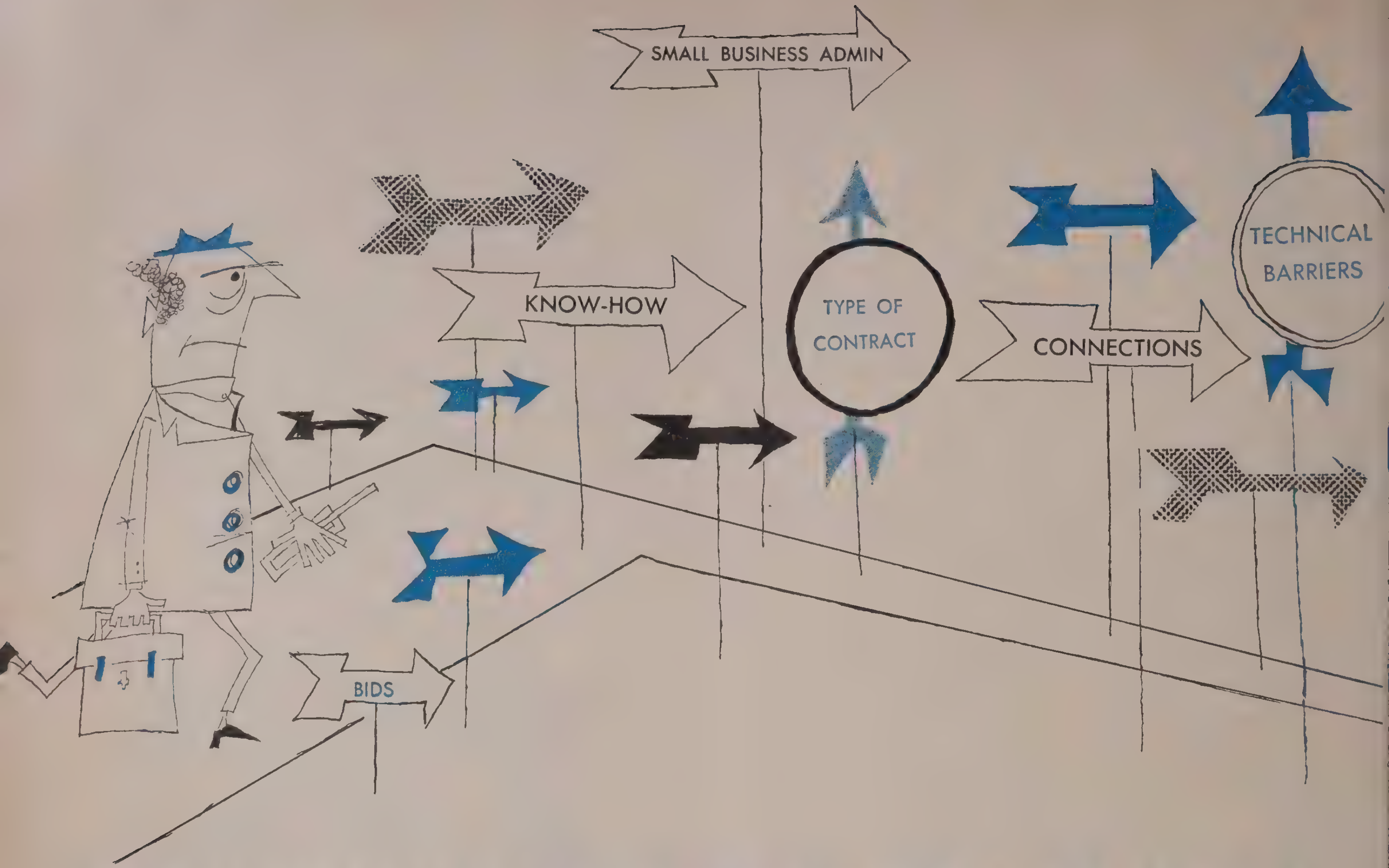


Silicon Stacks

Silicon rectifier stacks now combine the performance of silicon with the versatility of stack mounting. Designed for aircraft and missile applications, the rectifiers operate reliably at 150C with voltage ranges up to 5100 volts rms and 10amp current.

Developer: Transitron Electronic Corp., Melrose 76, Mass.

For more data: circle 25 on p. 48.



GOVERNMENT R & D CONTRACTS: Pitfalls and Procedures

MAX HOBERMAN

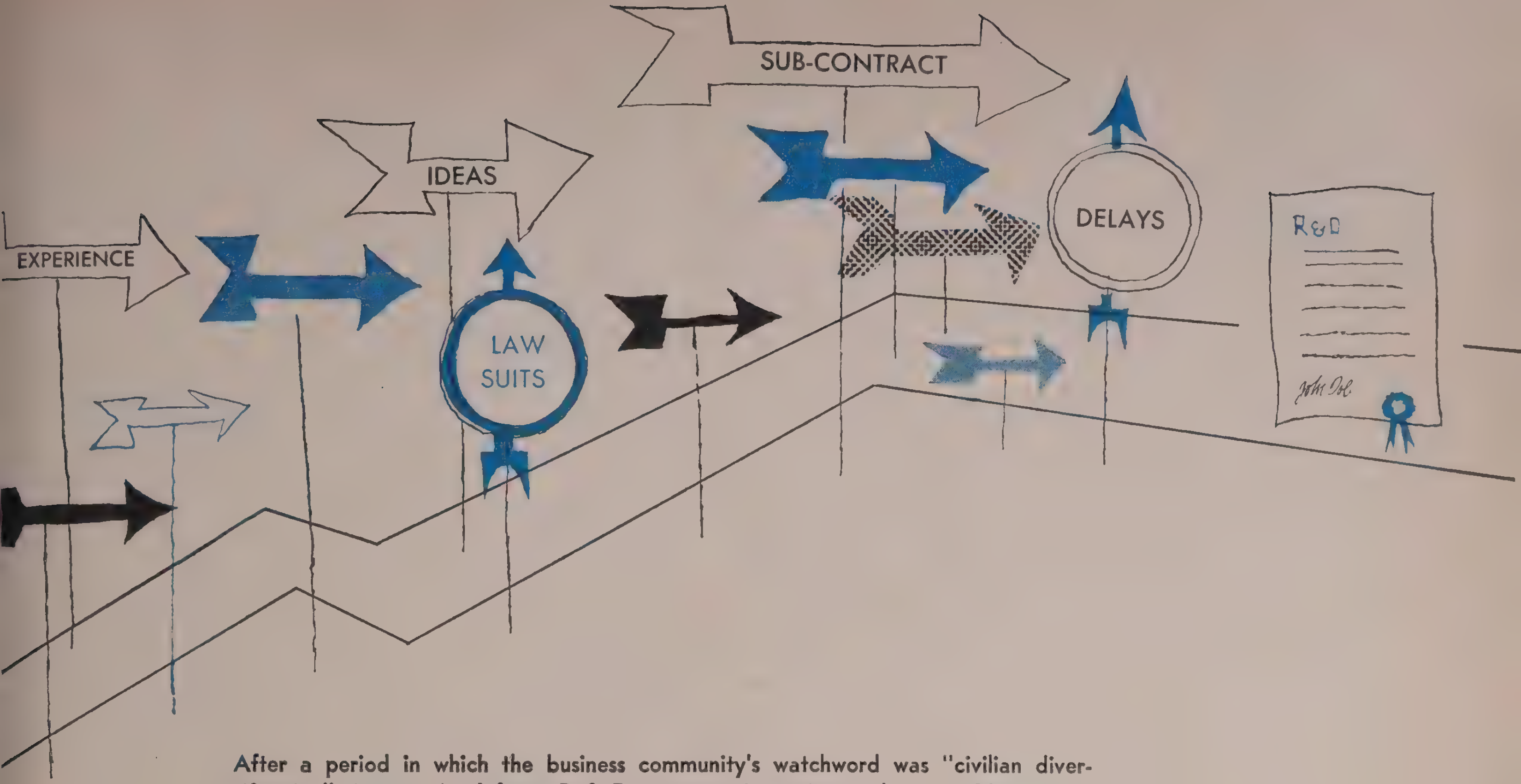
One of the most important functions of the engineering management of a company is to determine whether and on which government R & D contracts the company should bid, how much to bid, the nature of the technical proposal and methods which the company can use to take advantage of new developments made during the course of the contract.

There are many industrial companies which deal only with agencies of the United States Government, whereas others have no government business at all. The former are often desperate to obtain commercial products, and the latter are generally overeager to graze in the apparently greener pastures of "government contract business"; but the aim of progressive minded management is to strike a proper balance between the two. Dreams of lucrative, risk-free, "cost-plus-fixed-fee" contracts with all the business costs borne by Uncle Sam have often lead to disaster when a conscientious government auditor protecting your tax money (and his) insists that items charged to the government contract do not rightfully belong there. Don't expect a government contract to cover the monthly payments on the Chris-Craft Cruiser listed on the books, as "experimental test equipment". However, R & D contracts have many advantages which make them sought after by th[e] great majority of engineering organizations.

Research and Development contracts have many attrac[-]tions to the small business besides the obvious one of feed[-]ing the fires. An R & D contract well performed can some[-]times lead to production contracts for the items develope[d]. And this is the aspect which is often most lucrative. O[f] course there is no assurance that the company completin[g] an R & D contract will get the eventual production contrac[t] or that there will be a production contract. But the familiar[-]ity with the problems, and experience gained during develop[-]ment will give that company the edge in "know-how" whe[n] it comes to the production phase. There is an exception, how[-]ever. Very often a company doing the original developmen[t] will lose out on the production contract because a compet[i-]tor, in his ignorance of some of the difficulties, will bi[d] lower than he should. Many a production contract has bee[n] lost to the developing company in this way with the "suc[-]cessful" bidder ultimately regretting his action.

Conversion to Proprietary Products

Another very important attraction of the Research an[d] Development contract is the possibility of a company d[e-]



After a period in which the business community's watchword was "civilian diversification", interest in defense R & D contracts is again on the rise. Obtaining a government contract is not a job for an amateur. The key action is proper preparation of the technical proposal to best reflect your R & D resources. Here, an engineer who has prepared many of these proposals tells first what to expect and then how to go about it.

veloping a new product in a manner which is in effect partially subsidized by the government. Thus, the bidder who undertakes and succeeds in the development of a special thermocouple for aircraft may end up with a contract to supply these thermocouples to all military aircraft engines in this and foreign countries and possibly to many commercial aircraft throughout the world. A new product has been created where none existed before and a lucrative business has been built up around it. Contracts can also be obtained to adapt an existing commercial product to military use.

Finding Out About Govenment Work

Many companies have their own sales staff for the purpose of fishing around in government procurement offices to locate development business. Smaller companies may make use of technical representatives who are paid a commission for all business they procure. (These men may sometimes have to be registered as agents of the company. They may come under contingent-fee clauses of the invitation to bid.) A useful method of determining where the business lies is to write a letter to the various agencies indicating the nature of the business sought and the facilities for performing it. If the letter is in any way complete, it will stimulate a reply describing exactly what should be done to get on the appropriate bidders lists. Various government publications also list available contracts but these lists are usually devoted to production contracts.

A fruitful source of sub-contract work is to keep tabs on the contract awards as they are published, and to solicit business from these prime contractors. Of course, the time-tried method of knocking on the doors of purchasing agents of large companies is also a good source of sub-contract development work, but these "off-the-street" receptions are never as good as introductions via some mutual business acquaintance.

Help can be had from the local office of the Small Business Administration which is an agency of the government responsible for encouraging the letting of contracts to small businesses. The company's facilities brochures also should be sent to various price contractors such as aircraft companies who are looking for small companies anxious to do R & D work for them.

Pitfalls of Government Contracts

Newspaper accounts of Chicago sailor hat manufacturers seem to indicate that the government is quite naive and ready to be taken; the truth is that a contract with the government is as binding as any other contract. Government contracting officers are agents of the government and thus are handling someone else's money, they are sometimes apt to be quite strict in the interpretation of their duties. One company which had been doing a great deal of government work later dropped out of that field altogether, arguing that they preferred to deal as sub-contractors to other larger prime contractors, since these could very often be "touched" for an increase in contract amount by a hard luck story. Reasonable explanations of unanticipated costs or delay can often result in a sub-contract price increase, but a government contracting officer is under the eyes of his colleagues, Congress, newspapers and other auditors are constantly on the alert for indications of favoritism or fraud. As a result, requests for contract increases usually are met with a very chilly reception. To this end, more and

more of government "Invitations to Bid" come with a warning cover page (which must sometimes be read and signed, to be returned with the bid) indicating the seriousness of the bid.

A Bid is Binding

One typical case of a disastrous bid on a government contract occurred when a small company bid on the development of a special signal generator. They were particularly anxious to obtain this contract and bid about $65,000 to develop and manufacture 50 units within about nine months. They had never developed a similar unit before, which was one danger sign. The government agency procuring the unit (a non-military one) was notoriously low in funds and therefore strict in contract interpretation. In addition they required the posting of a $25,000 performance bond which the company obtained through a bonding agency rather than tie up so much money. Two years later, they still had not delivered a single unit, and were quite concerned with the possibility of forfeiting the bond, something seldom done as long as diligence of performance is in evidence. Unforeseen technical barriers, which prevented other more experienced companies from bidding as low, kept plaguing the development, but there was no way in which the company could avoid its contractual obligations, either legally or ethically. After a considerable loss of money the prototype unit was completed and deliveries began about two and one-half years late.

When there is evidence of machination or fraud, the government will strike with all of its legal resources which are quite extensive. About five years ago, a well known communications equipment manufacturer who had an unsavory reputation within the trade, and who was attempting to employ unethical techniques in his dealings with government agencies was sued and deliberately put into bankruptcy by one of the largest government procuring agencies. Despite the company's pleas of "persecution" to Congressional investigation committees, the bankruptcy proceedings were deemed just and allowed to continue. The government sometimes moves slowly, but can be quite furious when aroused.

Royalty Free License

The government generally has the right to a royalty free license to any proprietary product developed under a government R & D contract, if the idea for the product without further development was conceived by an engineer as a result of working on a military project. In the past some firms have attempted to circumvent this right by switching an engineer off a government project when he appeared to be on the verge of making a valuable invention. Despite such maneuvers, the government successfully protects its rights, usually with success.

Dealing With the Contracting Officer

Sometimes, the services are skeptical of all ideas they don't originate. Even if you come up with a proposed solution to one of the military problems published by the National Inventors Council, you may receive little encouragement. The key is to know the particular officer in the service who is very much concerned with the same problem. Unfortunately, the placing of many R & D contracts depends upon the personality of the contracting officer. In extreme cases, some feel you have to flatter his technical ego. Unscrupulous individuals can take advantage of contracting officers, but usually not for long.

Basic Research Contracts

Basic research contracts are most often let to the larger universities and research organizations of which the Stanford and Armour organizations are typical. Examples of this are the $60,000 contract just let to Harvard for Investigation on the Propagation of Radio Waves in the Frequency Range from 20 to 100 Kilocycles and a $65,000 contract let to Northwestern University for Research on the Structure and Activity of Catalytically Active Solids and others. However, it is not unusual for outstanding private organizations to obtain research contracts, particularly in those fields in which they are eminently qualified.

Occasionally these research contracts may take the effect of a subsidy to a university or other organization to build an maintain a staff and know-how in a special field of interest t the government agency, but these subsidies have also maintaine many a smaller private organization in operation when the need of the services were to preserve an organization which migh otherwise be dissipated. Since research contracts do not have a definite a termination goal as do ordinary development or pr duction contracts, it is apparent again that the services mu see a higher degree of integrity in the contractors.

Just as with other contracts, the best way to land one is t take advantage of every political, intellectual and business co nection one has available. This does not mean sub-rosa "i fluence" connections but rather the introductions which a available to anyone, such as a letter from a Congressman o political leader introducing the company to a military depar ment and requesting that the bearer be considered for appropr ate research work falling within his ability. It should be pointe out parenthetically that there is usually no better way to k one's opportunities with government agencies responsible fo letting research contracts than to attempt to use *political i fluence* since politics and research appear to be antithetical.

Research scientists and engineers have been successful obtaining research contracts for their companies by person contacts in the intellectual field, such as university friendship and professional society acquaintances. A former professor fro your school may be aware of a pressing need for research fro his contacts as a consultant to a government agency, and, fin ing no interest for this in his own department, may very oft be willing to tip off a former student with whom he is friend or who had a record of turning in his homework promptly.

Business acquaintances can also help in tipping you off available research contracts if their own companies do not ha the facilities or personnel to successfully tackle a job. And, is customary in the business world, they may expect the sam

Due to the uncertainty of research work, it is most unusu for such contracts to be let on any other than a cost-plus-fixe fee basis, which is another reason for discriminating again smaller companies. This permits the successful contractor devote his best efforts without the pressing need to deliver opera ing "hardware" for a cost which will show a profit, thus insurin that the government obtains the maximum for its research dolla

Although it is considerably more difficult than the abo methods, any company or individual who has an idea which h thinks would be of use to the government is perfectly free write it up as a technical proposal for a research contract, an submit it to government agencies which he thinks would b interested in the work. It is most important to include a sufficie description of the background of the individual, in order convince the services to entrust him with a contract of this so A stumbling block to this method of obtaining the contract the need for showing financial responsibility which, on th cost-plus-fixed-fee contract can be arranged by progress pa ments so that the individual or small organization need advan funds for only a month or two of operation.

It should be pointed out that due to the patent clauses in go ernment contracts, acceptance of government funds on a resear contract may bar the exclusive use of any patentable item whi may result from a research contract. This requirement has ve often been an important consideration in keeping companies an individuals from seeking research contracts.

The Technical Proposal

The request by a military or other federal agency to furnis a technical solution to a pressing problem and to bid on th performance of the work and manufacture of equipment genera ly comes in the form of a letter from a procurement officer buyer. This letter simply gives the details of the requiremen and includes as an addendum a carefully prepared, detailed ou line in technical language of the equipment required or work be performed. Each agency has certain requirements to be m in the formal form of the technical proposal and these are co tained in guides to the preparation of the proposal or "Quotatio

Guide". Numerous forms on the financial status of the bidder are also made part of the requisition.

All of these papers are the government's way of saying: "Here is the problem. How would you go about solving it? How much will it cost? Prove that you have the technical and financial resources to perform." A very careful, well-thought-out answer to these questions can land a contract running into millions.

The very first step in successful proposal writing is to become thoroughly familiar with the "Request for Proposal" issued by the government agency. All aspects of this request should be carefully studied so that no detail slips by. The Request for Proposal is carefully prepared by the government engineers and any apparent inconsistency in your bid proposal is usually attributable to carelessness in your interpretation of the request.

During the second or third reading of the request, the various contract requirements can be set down in an abbreviated form so that the original documents are condensed to a page or two. The overall picture should have begun to take form, but very often several points are not clearly understood. A telephone call to the contracting officer or engineer will often clear these up. Much better, however, are the personal conferences arranged by some government agencies with interested bidders to give everyone an equal chance to confer with and question the procurement personnel. The importance of understanding perfectly what is wanted cannot be overstressed. On one occasion, a telephone call to the cognizant project engineer to clear up a point was answered by him with, "What we *really* wanted was . . ." A proposal directed to what was *really* wanted, rather than what was apparently meant by the proposal request, landed the job.

When the proposal request is fully understood, the form of the solution may begin to take place. Frequently a thorough search of the technical literature on the specific problem will uncover possible methods of attack. Recourse to other branches of engineering to determine how a similar problem is solved in that field will very often help. Conversations with the various staff engineers of the company to obtain their ideas on solutions is probably the way most proposal requests are solved, but occasionally a proposal will seem to ask for the impossible. No method of solution appears evident. None of the personnel experienced in that field within the company have any ideas which look promising. The literature seems to be no help and allied fields furnish no clue. At this point the resourcefulness of the engineer and his inventive spirit can very often provide a solution.

Have Alternatives

It is well when proposing solutions to have several alternatives to describe, particularly when no single alternative is clearly head-and-shoulders above all others. This indicates an imaginative staff with a realization of the various aspects.

Another successful technique for finding solutions is to attempt to find a mechanical solution when an electrical or electronic method already exists, and vice-versa. A description of both kinds of solutions will often give the government reviewer ideas which may not have been considered by competitors.

When the possible methods of attack have been crystallized, several schematic diagrams of the proposed solutions, or block diagrams with details of the blocks on separate sheets can be drawn. One method is to draw these freehand, have copies made for one's own use and give other copies to a draftsman to be put into final form. Thus final drawings are being made while the balance of the report is being written. A time schedule which describes the weekly sequence in which the various phases of the Research and Development contract can be performed is very useful in focusing attention on the proper planning of the project.

One Request for Proposal described the desired form of the Technical Proposal as follows:

"The bidder must submit technical proposals and data sufficient for a technical evaluation. Your technical proposal should be precise, factual and complete. Practicality will dictate the extent of your proposal. Elaborate formal presentations, binders and the like are not required. Legibility, clarity and completeness are far more important.

Max Hoberman, Chief Engineer of Bergen Laboratories, Fairlawn, N.J., was formerly a Senior Engineer with Federal Telecommunications Laboratories and a department head at Avion Instrument Corp. Much of his efforts are in the capacity of consultant in the preparation of technical proposals for R & D contracts. He works in all branches of electronics and instrumentation.

1. State the method by which you propose to solve the technical problems of this project. Include detailed descriptions, sketches and plan of attack, sufficiently complete to permit engineering evaluation of the proposal.

2. Specify exceptions to the proposal technical project requirements or indicate changes you would suggest to improve the project as an alternate proposal.

3. State background experience in fields relating to this procurement.

4. State the equipment you now have available for use on this project and list separately any known additional facilities or equipment which will be required in the performance of this project.

5. Names and resume of experience of important personnel to be employed in this project.

Each of these sections must be carefully answered lest an incomplete report be cause for immediately discarding the proposal. The first requirement, above, necessitates a thorough evaluation of the problem and a detailed solution with the use of charts and diagrams. Most successful proposals design and plan as well as analyze a proposed physical solution. It is left for the actual award of the contract to complete detail drawings, manufacture, test and perhaps redesign the unit. A proposal to the Corps of Engineers for an automatic river stage measuring system (with automatic relaying to a central collating station) outlined on paper the various components, floats, mountings, radio transmitters, central station receivers and recorders. Vague statements such as "A radio transmitter with sufficient power output will be used" indicate insufficient preparation when compared with a proposal stating "The ABC Co. 50w transmitter model 111 operating at a frequency of 27.7Mc will be used to provide the requisite 15 mile range under all conditions." It should be pointed out that such technical committments made in a proposal do not usually prevent the contractor from substituting equal or superior alternatives when actual construction of a system begins. A statement to this effect in the technical proposal will prevent future misunderstandings.

The second statement of the sample quotation guide, given above, requires that exceptions to the project requirements be stated. However, it also states that changes be indicated which might improve the project. This is the government's acknowledgement that improvements over the requirements contemplated by the issuing agency may be conceived by someone reading the proposal request and that any such suggestions be included as an alternate proposal. This section permits the exercise of imagination to solve a proposed problem in a manner not easily seen.

Contracts are seldom let to companies which have no experience in fields related to the subject procurement. Exceptions to this are the cases involving organizations which are adequately capitalized and who wish to break into a new field. Frequently these companies have personnel who have adequate experience, possibly gained in a previous employment, to successfully perform research and development in the given field. The government has let contracts to such companies, but only after a satisfactory determination of the ability to perform. It is for this reason that the fourth and fifth statements above are given. Satisfactory answers to these can enable a company to enter a field which is not directly in the line with their business, thus adding needed diversification.

Financial Statement Important

Preparation of the financial estimate which must often accompany the technical proposal is secondary only to the actual proposal in importance. Corporation controllers often think it is *the* most important aspect and perhaps it is, but even the development of a tenuous thing like a system, component, or material not yet in physical existence must be bid for on a dollars-and-cents basis and is usually let to the lowest bidder.

Some service procurement guides are very specific in statements such as "It is in the interest of the Air Force to obtain the best procurement possible for the Air Force dollar." However this does not mean that in all cases the lowest price quoted will result in the award of the contract." As a result, the financial estimate accompanying the technical proposal must not be aimed at providing the lowest bid, but should instead provide the lowest bid for the work proposed. Arriving at the price to bid requires breaking down the proposed development into its small components, estimating the components and totalling the individual estimates, very much as is done in estimating any other job. However, in the R and D contract, there is very often no direct previous experience to assist in estimating the proposed bid. The various staff personnel who are most concerned with the individual aspects of the project are often reluctant to estimate the cost of say, experimental machine work or drafting when the actual components to be fabricated or drawn up are as yet unknown; there is a natural reluctance to go out on a limb. Still, reasonable approximations of a final cost can be obtained by comparison with previous projects of apparently equal complexity, by estimates of the various group leaders and by a more detailed preliminary design to establish a more close approximation of the finished development prior to entering the bid.

Occasionally the bid price is directly tied in to the performance to be guaranteed. Thus, in an instrument to be installed into aircraft, a formula was given based on the system accuracy, the weight and the bid price, as follows:

$$\text{Merit} = 100 - C_t - \frac{W}{3} - \frac{C}{\$20{,}000.00}$$

C_t is equal to the system accuracy (%)
W is equal to the weight of the system in pounds
C is the bid price

The company whose merit figure was the highest was the one to be awarded the contracts. It is apparent that 1% of the system accuracy was equal to three pounds of weight and these were equivalent to $20,000 of bid price. A careful analysis of the expected system weight and system accuracy was therefore worth $20,000 in the bid price for each 1% or three pounds.

Types of Contracts

The form of contracts let by the armed services range from the fixed price familiar to most industries through to the cost-plus-fixed-fee which is the minimum risk arrangement. To minimize the cost to the government, the services request that bidders consider underwriting part of the proposed development in the realization that benefit very often accrues to the bidder in the form of knowhow and new products. However, the services realize the risks inherent in some developments by offering contracts on a cost-plus-fixed-fee arrangement. In this form, the contractor bills the government regularly on the basis of direct labor costs, materials and overhead at a rate which is negotiated prior to issuance of the contract. A fixed fee which is most often a percentage of the total contract value is included as profit upon completion of the contract. This fee is earned even if the contract is successfully completed for a smaller amount than projected, thus the incentive to earn a higher rate of return on investment. Costs are very carefully monitored by the government on the CPFF contract and a separate accounting system to isolate costs is most often required.

The fixed-price contracts generally include renegotiation clauses which prohibit excessive profits from government contracts by permitting a redetermination of costs after completion.

The above two are the most common forms of contracts wi[th] the government and preparation of the technical and financ[ial] proposal for a government research and development contra[ct] must consider the advantages and disadvantages of either for[m].

Checklist for Technical Proposals

Use this list as a final check on technical proposals. Once mailed, a proposal can become a contractural obligation.

GENERAL

( ) Demonstrate ability to perform by citing similar projects previously undertaken.

( ) Give proof or adequate assurance of reliability in meeting delivery dates as promised.

( ) Show workmanship as determined from other projects.

( ) List production capabilities.

PHYSICAL PLANT

( ) Adequacy of plant

( ) Adequacy of production and test equipment

( ) Plans for proper inspection

PERSONNEL

( ) Relative experience

( ) Professional qualifications

( ) Availability of proper personnel

( ) Sufficient man-hour capacity

TECHNICAL

( ) Understanding of problem

( ) Soundness of approach

( ) Unique ideas

PECULIAR TO A GIVEN CASE

( ) Size and weight

( ) Equipment growth potential

( ) Ease of maintenance

( ) Simplicity of design

( ) Applicability to mass production

POSTAGE

( ) Have you put sufficient postage on the bid envelope? Do you know it cannot be accepted if there is "postage due"? That bids received late because of return for postage cannot be considered.

Come On In! The Water's Fine

The government wants as many companies as possible biddi[ng] on R & D contracts. That means better equipment for our mi[li]tary services. For many companies not now in the swim, su[ch] contracts could be a shot in the arm. Bearing in mind the hazar[ds] of the course, any good R & D organization can break par.

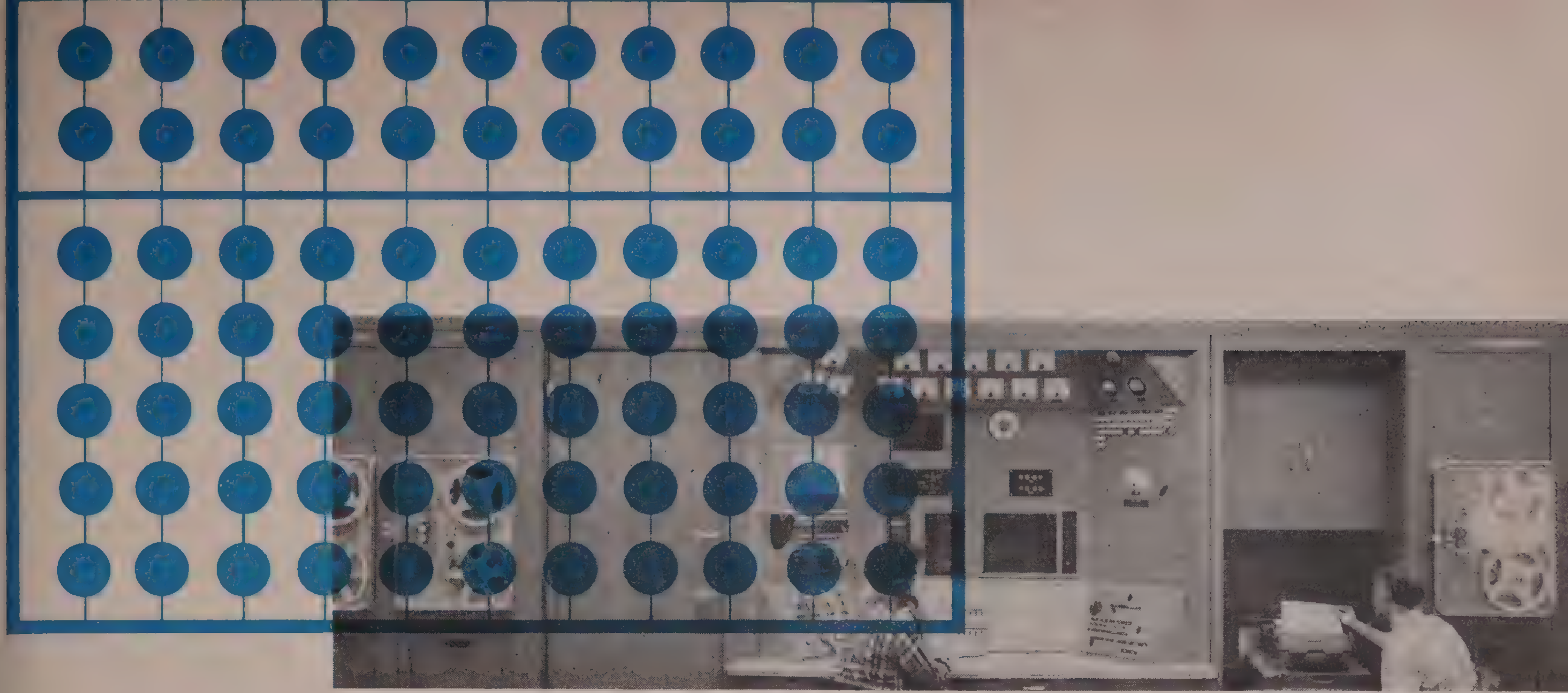


PHOTO COUTESY NATIONAL ADVISORY COMMITTEE ON AERONAUTICS

THE AGE OF RESEARCH

$5 billion investment in abundance

'PUSH-BUTTON PEACE'

The following article except for illustrations, is reprinted in its entirety from the July 9, 1956 issue of "TIME" magazine. It represents a departure from our policy of not publishing any material that has appeared in print previously. In this case, however, we believe that you who may have missed that issue of "TIME" would want to have it called to your attention—for this reason: Your primary business interest is engineering research and development; it is also our primary interest, as publisher of a magazine devoted to furthering the business of research and development. Both of us have certainly been aware of the gigantic increase in R/D activity during the past 10 years; in fact, in the very first issue of this magazine, July 1955, in our "Prospectus" page introducing the magazine to you, we made the following statement: "We believe we are on the threshold of a new age, the Age of Research". *Perhaps you, like this publisher, may have at times wondered whether we were devoting our business lives to an activity that is unrewarded and unrecognized. It is therefore gratifying to see our work being brought to the attention of the general public as evidenced by this story from "TIME".*

Although a substantial part of R/D work must of necessity be allocated to defense, the majority of our work is devoted to better, easier labor and living for our people—in the form of thousands of new or improved materials or products, from electronic Abacuses to the delightfully foaming products of Zymurgy. We feel that you, as an industrial technical manager, will welcome this public recognition of your work as a vital new factor in industry.

WM. H. RELYEA, JR., Publisher

IN a South Chicago building, three miles from the stadium where the world's first atomic pile went into action 14 years ago, a shrilling alarm bell signaled the birth last week of U.S. industry's Atomic Age. As a white-smocked scientist twisted the knobs on a control panel outside a monolithic concrete cubicle, a lighted dial flashed: REACTOR ON. Thus the world's first nuclear reactor devoted exclusively to industrial research went into operation at the Illinois Institute of Technology's Armour Research Foundation.

The $700,000 reactor, owned jointly by the Armour foundation and 24 companies, whose interests extend from food preserving to watchmaking, will hasten the new knowledge on which U.S. industry is building an Atomic Age technology. In the atomic furnace, physicists will explore the structure of metals, search for new plastics, investigate new ways of refining oil, new uses for rubber. Radioisotopes from the 50,000-watt reactor will be used by industry as tracers to track friction damage in machinery, test new chemical carriers for cancer therapy, hunt new manufacturing techniques in fields ranging from rubber to building materials.

The Chicago reactor is a concrete-shielded symbol of an economic force more far-reaching even than atomic energy. The force: research in industry. In the past 15 years a torrent of technological change has brought the U.S. greater material advances than any other nation has experienced in all history. With every breakthrough in the laboratory, industry has turned the new knowledge into new products for a society whose inventiveness has made achievement the bright converse of obsolescence.

From the test tube have come drugs that helped add eight years to life expectancy in the U.S. (from 62 to 70 at birth) since 1941, boosted population. At the same time, to the discomfiture of Malthusians, new fertilizers, insecticides and other chemicals have helped pile up the greatest food surpluses ever. Man has learned to cruise undersea on nuclear power, fly at supersonic speeds; research has trebled the number of metals used by industry, made diamonds from common carbon, and conjured up thousands of new products.

The revolution in living wrought by research is just beginning. Within a few years these things will be available:

- Houses with centrally controlled pushbutton windows, electronic heating, cooling and refrigeration systems that work without moving parts, electroluminescent lighting from sheets of glass and metal.
- Food sterilized by atomic radiation so that it will keep indefinitely without refrigeration.
- Chemicals that will kill all plants in a field except those the farmer wants to grow.
- Telephones with automatic worldwide dialing. TV screens for face-to-face phone conversations.
- Electronic computers that will design bridges and highways,

specify the construction materials, estimate building costs and future revenues from tolls.

- Home laundry equipment that will automatically pick up, sort, clean, iron and fold the wash; cleaning machines that will wash, rinse and dry a kitchen floor in minutes.

To hasten the flow of technology from laboratory to living room, some 3,000 U.S. companies today have their own research facilities, employ 500,000 research workers, including 100,000 scientists. Across the U.S., new research plants are springing up almost as fast as factories. In the past two months alone, General Motors dedicated its $100 million Technical Center in Detroit; U.S. Steel opened a $10 million laboratory at Monroeville, Pa.; Union Carbide & Carbon Corp. moved into a $6,000,000 Parma (Ohio) research complex; General Electric completed a $5,000,000 Cleveland laboratory for the study of "psychological and physiological effects of lighting on humans, animals and plants." Other multimillion-dollar research centers are being blueprinted by Ford Motors, General Dynamics' General Atomic Division, Westinghouse Electric, Koppers, Gulf Oil.

From the starveling stepchild of industry, scientific experimentation has become an industry in itself—perhaps the key industry. By constantly creating new products, and thus new markets, research has added a dynamic new force to the economy to help keep the boom rolling. Once industries competed for a market that seemed clearly limited by consumers' needs, and the basic needs varied little from decade to decade. Periodically, the needs were so nearly filled that the market and industrial activity declined. In the age of research, industries compete constantly to create new needs, expand their markets and increase production. Says General Electric's Research Director C. Guy Suits: "To an increasing extent, we will determine what discoveries need to be made—and then make them."

The U.S. today is spending $5 billion a year for research, or more in one year than in all the years from 1776 to 1933. Research expenditures by the Government, inconceivable in 1900, now total more than the entire cost of Government in that year. There were only two nonprofit scientific organizations in 1936: Battelle Memorial Institute in Columbus, Ohio and Pittsburgh's Mellon Institute for Industrial Research, with an annual volume of $1,100,000; now such institutions total 48, take in $100 million yearly. Moreover, the total U.S. research effort is growing at the rate of 10% to 12% a year *v.* an average annual increase of 3% in the gross national product.

The power behind the research race is industry's new-found ability to harness science and invention to production, systematize the search for knowledge by pressing the scientists into service in the industrial laboratory and project team. The swift spread of research has caused a redrawing of the traditional picture of the lone scientist or inventor experimenting in his own workshop and, with his own flash of genius, discovering a new principle and founding a new industry. Now task forces that may number hundreds are thrown into a project; with the help of such research-developed equipment as computers, they can explore in a few weeks problems that would take an unaided worker years. In Detroit, where Henry Ford once puttered with his new car in an old stable, while his wife held the lantern, Chrysler Corp. has 200 scientists and engineers assigned solely to gas-turbine engine development.

One big effect of the task-force approach has been to eliminate the rigid boundaries that once separated one science from another. Oilmen are experimenting with radiation; atomic scientists are exploring the properties of oil. The electrical industry has unearthed new chemicals, *e.g.*, silicones, used in products ranging from synthetic rubber to children's "silly putty". Mathematicians have helped neurologists chart the workings of the brain. Working side by side, specialists in all fields have developed new families of alloys and plastics, found new uses for old, abundant materials.

Industry executives, who once minimized outlays for science because they were hard to justify to stockholders, play up research budgets as a powerful magnet for new capital. Reason: securities analysts and bankers have come to regard a company' research program as one of the most significant yardsticks o its future growth and ability to keep up with—or outdistance— competition.

Chemical companies such as Dow and Monsanto, among in dustry's heaviest spenders for research, trace 30% to 40% o 1956 sales volume directly to products developed through researc in the past ten years; agrichemicals alone—fungicides, herbi cides, insecticides, etc.—have become a $400 million-a-year in dustry in less than a decade. Standard Oil Co. (N.J.) estimate that every $1 invested in research will return $5. Internation Business Machines Corp. (research budget: $19 million) say that every product it sells today was developed from researc The U.S. as a whole, according to National Science Foundation Director Raymond Ewell, has earned back $2,000 to $5,000 fo every $100 spent for research and development in the past 2 years.

Most industry-sponsored research falls into three categorie 1) basic—the search for new knowledge with no immedia thought of commercial application but within the general fram work of the company's interests, 2) applied—the hunt for specif information for practical purposes, and 3) development—con verting theory into products or improved production processe

Basic research is the least predictable and usually the chea est. Applied research is costly, and it gets still more costly as turns into developmental research. To test new ideas, moder industrial laboratories have all the production facilities of fa tories. In the big laboratories, some $25,000 to $50,000 is in vested in equipment for every scientist employed. Because o this progressive cost, most companies cannot enter the researc field unless they have some hope of commercial results.

Nevertheless, the companies that have delved most deep into fundamentals have in most cases come up with the riche booty. Du Pont's nylon came from basic research into molec lar structures started in 1927 by Du Pont's late famed Scienti Wallace Carothers. When Dr. Carothers found a way to sim late the long-chain molecules found in natural silk, Du Po applied his findings to the development of nylon, which reache mass production in 1939, after five years and $27 million fo applied research. European scientists were quick to capitali on Carothers' findings, developed other synthetic fibers. Whe Du Pont used Carothers' research to produce Dacron and oth synthetic materials, the U.S. company found that it had to bu manufacturing rights from European concerns. Du Pont's late dividend from Carothers' research is rubberlike urethane foa used in a wide variety of end products from furniture to falsie Urethane production has increased tenfold in the past yea should reach the 100 million-lb. mark by 1960.

By giving top scientists the widest latitude, Bell Telepho Laboratories, the $113 million-a-year research arm for Amer can Telephone & Telegraph Co. and Western Electric, has stru some of the biggest pay lodes in industrial history. In 1948 Be Mathematician Claude Shannon, projecting earlier studies b Massachusetts Institute of Technology's Norbert Wiener, pu lished *Communication Theory*, a complex mathematical schem for measuring information content in communications, as we as evaluating the performance of systems that transmit wor and pictures. The theory opened new horizons in telephone an TV transmission, has already found its way into the Air Force Distant Early Warning (DEW) radar fence.

Another Bell breakthrough in 1948 was the discovery, aft years of basic research into the structure of matter, that solid metal such as germanium or silicon (earth's most abu dant solid element) can be made to act like a vacuum tube, *i.e* it will amplify an electric signal. Result: the flea-size transist —and a king-size new industry. Thirty-five manufacturers ha already turned out 7,000,000 transistors *v.* 1 billion vacuu tubes now in use in the U.S., are doubling output each yea Transistors will multiply the speed of future telephone exchang 1,000 times; they have infinitely refined and compressed th performance of electronic computers.

Thorough patent-licensing, most big U.S. companies share the ruits of basic research. RCA has earned enough income from oyalties and Government contracts since 1947 to make its reearch program self-supporting. Thousands of patents develped by Bell Labs may now be used by other companies withut charge, as a result of the trustbusting consent decree signed ast January by A. T. & T. and Western Electric. Eastman Kodak stimates that at least one-third of 1,800 basic studies published y its researchers have benefited industry as a whole.

Applied research also turns up rich and diversified rewards. Chrysler Corp.'s research in hydraulic pumps for cars resulted n a hospital pump that delivers liquefied natural food directly o a post-operative patient's stomach, eliminating the need for ntravenous feeding in many cases. General Motors' developnent of a sensitive device to test automotive parts yielded an lectronic "stethoscope" for doctors.

Applied research can often turn migraines into moneymakers. n the manufacture of chlorinated biphenyl, widely used for nsecticides, Monsanto's Anniston, Ala., plant was swamped by useless fluid residue. But when researchers found a new producct, HB_{-40}, that uses the waste fluid to give greater flexibility o plastics, Monsanto salvaged twelve million pounds of storedp residue, started making the onetime waste product.

Despite the task force approach, research is not a monopoly f the big companies. Many small companies that cannot afford ull-scale research programs of their own can hire top outside rains to solve their scientific problems. Companies such as 3. F. Goodrich and General Dynamics specialize in product levelopment to fit other companies' requirements. Even corporations with their own big laboratories often hand over reearch projects to scientific contractors such as Boston's famed Arthur D. Little Inc. (1955 gross; $11 million), whose 800-man esearch staff has developed products ranging from rubber ement to a better instant coffee. Research is also farmed out o nonprofit institutions and universities, which, before World Var II, had a virtual monopoly on basic research.

Some companies still contend that fundamental research should ll be done on the campus, where it is free from sales-department ressure. Others work closely with universities. Du Pont helps eep in academic touch by retaining 70 university professors s consultants. Many company research centers, *e.g.*, G.E.'s chenectady laboratories, cultivate a "congenial" atmosphere of cademic leisure. Industrial jobs frequently give top scientists reater freedom than university posts.

How does management decide whether research will pay off? ays one executive: "You're always on a tightrope. Either you pend too little for research and your product is years out of ate, or you spend too much and it's years from production." 'o cut the average ten-year time lag from test tube to cash egister, most companies rigorously analyze even the most romising leads in terms of cost, marketability, timeliness and racticality, reappraise the potential new product at every tage of development. At Bell Labs, systems engineers spend ears checking research developments against rival theories and he existing mechanisms they will outdate. They argue: "If it orks, it's already obsolete."

Some companies allot to research a fixed proportion of sales from less than 1% for transportation companies to more than % for big electrical and chemical manufacturers), give reearch directors a free rein in pursuing likely leads. Esso Reearch measures each venture by its "probability ratio," *i.e.*, he value of the potential product, multiplied by the probability f successful research, divided by the cost of the work.

Du Pont compiles its annual research budget according to he cost, duration and number of all approved projects, usually pends about 3.5% of sales (1955 research budget: $70 million). ven so, few research ventures last the course. One-third of he studies undertaken by Du Pont's chemical department are laboratory flops"; 50% are successful in the lab but prove npractical for production; less than 10% goes to a manufacuring division for development, and only a small fraction of these ever goes into production. RCA estimates that 90% of its research ideas are useless; from the other 10% come 80% of all the products it sells today. Says RCA Laboratories' Vice President Douglas Ewing: "Research is never a blind alley. Learning what is not feasible is perhaps nearly as important a step forward as learning what is. Research is a process that corrects its own mistakes."

The biggest problem for industry is the time and the money it must lavish to turn theory into product. A new amplifying device for transoceanic cable was tested for 20 years before A. T. & T. decided to install it in a sample cable. Penicillin, invented for $20,000, cost millions to prepare for commercial use. RCA had invested $50 million in TV before it reached the U.S. living room, has another $30 million tied up in color TV; telephone companies buried millions of dollars worth of coaxial cable, engineered with TV in view, long before they had network customers. Monsanto tested 15,000 chemical compounds at its Creve Coeur, Mo. laboratories to find a herbicide that would kill weed grasses but not harm corn or soybeans, spent six years and $750,000 on the product, which has yet to be marketed.

Nevertheless, say many scientists and industrial leaders, U.S. business is not investing enough for the basic research that nourishes all invention. These critics argue that industry should allot at least 10% of its research outlay for fundamental studies *v.* the 5% average. The U.S. Government, which underwrites 60% of the national research effort, also tends to emphasize practical rather than theoretical value. At least 93% of Government research money placed with industry goes for specific projects; $4 of every $5 in Government research grants to universities also specify applied research. Says Whirlpool-Seeger President Elisha Gray II: "The paucity of support for basic research could be our Achilles' heel."

Historically, the critics are right. The technological advances of the past century have stemmed from uncommitted experimentation. As G.E.'s Nobel Prizewinning Irving Langmuir points out: "Only a small part of scientific progress has resulted from a planned search for specific objectives. A much more important part has been made possible by the freedom of the scientist to follow his own curiosity in search of truth."

But the cost of research is not the only obstacle. Many industries are cramped by the shortage of scientists. Company interviewing teams comb through the new crop of graduating students each year, and educators complain that only the rejects will be left to teach. Moreover, many potential research men shy away from science because the starting pay in industry ($700 a month for a Ph.D) is too low.

Top research men often fear regimentation in industry. An even bigger problem is that scientists who get limited freedom to do original work often are not creative enough to use the opportunity. Research directors also argue that young U.S. scientists lack the dedication and driving intellectual curiosity of the forebears. Says RCA's 41-year-old Dr. Ewing: "For some reason, really creative ideas come only from those under 40. Perhaps adversity and unsureness compel creativity."

Somehow, the U.S. must increase its creativity. The nation, which has increased its energy consumption 50-fold since Jefferson's day, will need 90% more power capacity by 1965; in that decade, say experts, fossil fuels will be so depleted that the nation must have competitively priced nuclear power. To feed and clothe 193 million population by 1975, U.S. farms will have to boost output. Spiraling metals consumption will intensify the search for new ore deposits and new ways to extract metals from clay and sea water. To meet 1965's demand for 50% more goods and services with only 10% more manpower, automation will have to move into industry's front line. Despite its sevenleague strides into the future, science has yet to overcome scores of existing problems, from the nation's $10 billion annual loss from rust and rot to the $2 billion yearly road-repair bill.

Almost no leader of science or industry doubts that the U.S. can and will develop the knowledge to meet the challenge through continued research.

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R. C. VICKERY, Contributing Editor

We study water physically, chemically and economically, know its densities, expansibilities, thermodynamics, conductances—everything, in fact, except where our next industrial drop is coming from. For the U.S. is faced with an increasing shortage of fresh water. Conversion of sea water to fresh water appears to be the most feasible solution, so here's the latest on demineralizing saline water.

The mass of water on our earth is of the order of 14×10^{17} metric tons, or roughly seven percent of the earth's total mass. Oceans and seas cover almost three quarters of the earth's surface to an average depth of about two and one half miles. Our bodies are approximately 95 percent water —each adult represents, therefore, nearly 160 pounds of consolidated water. Yet we know little, or less, about this essential natural mineral than we do about the scores of other mineral resources and bodily requirements which represent less than one-tenth percent of the masses of the earth or our bodies. We know more about the treatment, purification, and uses of high-grade iron ore, or low-grade alkali deposits than we do about water. Human life is inexorably associated with the molecular species derived from the combination of two hydrogen and one oxygen atoms, yet we are still economically and physiologically unsure of this basic requirement.

Natural waters are never wholly pure or typical, but in any condition are our most important natural resource. Some of the artificial devices of our way of living require the absence of water in any form—humidity engenders corrosion, malfunction of electronic devices, etc., and even the human body has to treat water with respect—mere fluid ounces can cause death under some conditions, and floods cause havoc.

Just what do we know about water, physically, chemically, and economically? Densities, expansibilities, thermodynamics, conductances of the three states, are almost standard extremes—but what do these standards mean? The existence of polymerized species (dimers and tetramers) in all states of water is now accepted and we know that ionizing radiations decompose water molecules, yie ing hydrogen, oxygen, and peroxide. We also know th water is the most important solvent in existence and know it has extreme catalytic properties. Heavy water, which normally occurring hydrogen is replaced by heavier isotope deuterium, is of high importance in ma nuclear energy projects. But none of these data can tell where our next drop of water is coming from.

There have been many arguments about the relat values of fundamental versus applied research, but in other area have we so much overemphasized fundamen research as in our studies on water.

Daily precipitation in the United States is approximat 4300 billion gallons, of which some 70 percent recyc hydrologically. Thirteen hundred billion gallons of wa are therefore available daily. Total industrial water usa during 1953 was 11,430 billion gallons and in 1956 w probably attain the 12 trillion gallon mark. Even assumi an average private water requirement of three hundr gallons per head per day, total water consumption in t nation—industrial and private—is only 358 billion gall per day; why, then, are there increasing indications shortages of fresh water throughout the United States well as in other regions? Many areas on the East coast a seeking adequate water sources to serve their growing pop lation in the face of over-taxed supplies and increasing p lution of streams and other waters. Growth of communit in the West is restricted by lack of potable waters.

The problem is basically one of distribution and run-o which is fundamentally determined by geography. Erect of reservoirs or dams and elementary coastline variat

might eventually solve the problem, but cannot provide that immediate and continuing solution, however partial, which is so drastically required.

The Ocean: Our Next Reservoir

For many years men have talked and written of extracting plentiful supplies of fresh water from the ocean, and many techniques and processes have been suggested for this purpose. We know how to remove salt from sea water, but saline water conversion is still too costly a process.

Technically feasible methods of producing fresh water from sea water or brackish inland waters have been known for many years and some of these have been practiced on a large scale in various arid regions in which high operating costs may be accepted. Current research shows, however, a gradual progress towards cheaper methods of production; a close approach is now being made to the maximum existing costs of municipal water.

There have been, and are, several different approaches to this situation. By improved plant design, heat transfer in distillation processes can be increased five to ten times; electric membrane processes achieve good potential efficiency and low costs, while osmotic processes and solar distillation promise efficient production.

The chemical nature of the problem is essentially simple. Table 1 lists approximate compositions of sea and brackish water, together with that of an average potable water. Analyses of sea and inland waters will vary considerably with different localities and the potable-water specification could be varied appreciably according to the nature of its use, since, at a rough estimate, nearly a half of our so-called "potable water requirement" is used for sewage and waste removal purposes (Table 2).

Brackish inland-source water is well suited to normal municipal treatments of coagulation, sedimentation, filtration, and disinfection. While research progresses on the techniques employed, the basis for current methods may be considered adequately laid, although situations develop occasionally requiring modification of standard treatments. This situation is, however, inadequate and it is because of this that further work must be done on the conversion of saline water for domestic and/or industrial usage.

Sea water contains approximately 3½% of dissolved solids, the total range for United States coastal surface water being 3.25 to 3.62 pounds per 100 pounds of sea water; lower depth ocean water is more constant in total salt content—3.46 to 3.50 pounds per 100 pounds. Less saline water occurs in the estuaries of the larger rivers and off those of the smaller rivers draining regions of very heavy precipitation, but this is of little value, since fresh water is generally plentiful in these locations.

From oceanic "brine" containing 3,500 ppm dissolved solids, a "potable" water containing <500 ppm of solids must be obtained. Many cities supply water from natural sources considerably below this limit (Los Angeles: less than 200 ppm; New York City: less than 50 ppm), and many cities whose natural supply falls in the range of a few-hundred ppm use artificial softening systems or treatments to bring total solids down to 85 ppm; however such softening systems are chiefly used for soap economy rather than health reasons.

Irrigation water is usually judged by three criteria: boron concentration, ratio of sodium ion concentration to the sum of sodium, potassium, magnesium, and calcium ions, and total dissolved chemical content. No more than 3 ppm of boron is permissible for even the most tolerant crops, such as alfalfa and sugar beets, and only 1 ppm for fruit trees. Since sea water contains 4 ppm boron, a considerable reduction is necessary in this particular content. Too much sodium in irrigation water makes the soil sticky when wet and form clods when dry. These effects are counteracted by calcium, magnesium, and potassium ions, and additions of salts of these elements may under some circumstances be permissible up to a limiting ratio, $Na/Ca, + K, + Mg, + Na$, of 60%—for sea water this ratio is 84%. A maximum permissible solid limit is given of 500 to 1400 ppm, while at less than 175 ppm the water is considered excellent for irrigation. Low solid and soluble salt values are required because of build-up in solid by evaporation.

Generally, exit water from any sea water purification process must contain no more than 1000 ppm of dissolved salts, with special attention being paid to sodium and boron content, and it is to this end that studies are directed.

Work Is Government Sponsored

Current work in this field is in the main sponsored by the Government although additional investigations have been conducted by others. Regardless of origin, however, current studies are those basically involving:

Thermal distillation: vapor compression; compression and multiple effect; critical pressure

Solar distillation: single stage, roof-type still; inclined glass still; plastic-covered still

Electric membrane separation: electrodialysis cell development; membrane synthesis; fundamental membrane research

Osmotic processes: pressure osmosis; air-film osmosis; osmionic process; adsorption osmosis

Solvent extraction of water

Separation by freezing: countercurrent washing of ice; compression separation; zone freezing

Other processes: ultra-sonic vibrations; high-frequency currents.

Distillation processes for demineralizing saline water date back many hundreds of years. Distillation equipment is in wide use for supply of fresh water to Service and industrial utilities requiring high-purity water and, until recently, studies in this field were almost wholly directed towards the particular problems encountered in these areas. During the past few years, however, there has been an increasing awareness of the potential demand for civilian uses.

Apart from solar heat distillation processes, there are at present two principal types of saline water distilling apparatus—vapor compression and multiple effect. Each has advantages; in general, vapor compression apparatus, is more difficult to operate, but requires less fuel, whereas the multiple-effect system is more readily adaptable to operations involving sources of low-cost steam or waste heat.

One of the prime difficulties in economic distillation of

sea water is determined by scale formation at 160°F. Scale impedes fluid circulation, fouls the heat-transfer area and imposes higher operation costs, all of which result in decreased production.

The potentialities of large-scale combination multiple-effect systems have been increasingly studied and work has been aimed at correlation of variables affecting unit design and operation, i.e., heat-transfer element shape and movement on the transfer rate, together with additive effects of operating temperatures, pressures, and rates of evaporation.

Studies on forced circulation and drop-wise condensation techniques for improving heat transfer have shown that rates of 1900 to 2300 btu/hr./sq. ft./°F may be obtained consistently. These rates compare with the coefficients of 500 or less obtainable in current types of equipment. Equally important is the reduced scale formation inherent in such forced circulation—flash-boiling operations. Such systems can be expected to yield pure water with an energy expenditure of 14 btu per pound (about half the best previously reported figures for vapor compression), and thermodynamic analyses indicate that a figure much below this value cannot be expected of any practical vapor compression system.

The major economic problem of distillation processes is the large energy input normally required and a number of modifications aimed at minimizing this have been proposed. One of the most effective techniques suggested is that of employing very high pressures and temperatures. Under such conditions the distillation of sea-water brine approaches ordinary vaporization processes; however, as heat is applied the temperature of the vapor and liquid mixture rises and this makes necessary the design of a plant permitting recovery of the process heat with a consequent diminution in net energy consumption.

Solar Processes Encouraging

Solar processes are encouraging, particularly in dry areas of high solar intensity. Current studies suggest that direct use of solar heat in distillation equipment of simple design offers the best and cheapest possibility of producing fresh water from brine. On this basis, still designs have been developed and tested, utilizing sheets of absorbent material as evaporation surfaces. A possibility of major importance lies in the design of a large-area, roof-type solar still based upon an engineering approach quite different from that previously used. Estimates of cost and performance have, however, been based generally upon results obtained on very small installations, and reliable estimates of maintenance, operating costs, and overall performance of large-scale stills have been unobtainable by extrapolation of small-scale data.

Meanwhile, among the numerous methods and types of equipment for solar distillation, the best prospect for economical application appears to be the simple solar-heated evaporating pan, covered by a transparent surface serving as a condenser. Although some of the more elaborate systems can produce considerably more distilled water per square foot of solar-absorbing surface, they suffer from low load factor on the expensive evaporating equipment, and the total cost of the water produced is higher.

There remain for solution, however, several constructional and operating problems—high cost of original equipment and installations, maintenance difficulties, unsteady operation, leakage of vapor and liquid, and general unsu ability for very large-scale operation.

However, a design has been drawn up for a one-acre se water distillation plant with an expected capacity of least 5000 gallons of potable water per day in a clima such as that of southwestern United States.

The design is based upon an engineering approach qui different from that previously used in experimental sol distilling units. The still is of concrete, directly on t ground without bottom insulation. The basin contains one-foot depth of water rather than the shallow (one-ha to two inches) layer more commonly employed, and t large single basin is subdivided into smaller basins means of concrete curbings which serve as glass support condensate troughs, and tracks of movement of maintenan vehicles. The glass covers are sloped at an angle of 10° to a center ridge bar, and the arrangement is such that i coming and outgoing streams of water can undergo ea and economic heat exchange. Maintenance, cleaning, r placement of glass, and routine operations also should easily and cheaply effected, while construction costs of large-scale unit should be below one dollar per square fo of distiller.

Membrane Demineralization

The principles of membrane demineralization have be known for many years, but this practical application h awaited suitable membrane and engineering technique Both of these are of only relatively recent development. E sentially the system is one of electrolysis through permeab or semi-permeable membranes. The membranes, carryin either positive or negative charges, are set up with a pos tive membrane adjacent to a negative one and with wat passages between each two membranes of consecutive pair On electrolysis positive salt ions migrate in one directio and negative salt ions in the other so that water passir between alternate membrane pairs is depleted of salt, whi that between intervening pairs is enriched. Such a syste reduced the dissolved salt content of an irrigation wat supply from about 4000 ppm to about 350 ppm. Much dif culty arises, however from "fouling" or "plugging" of th membranes and flow channels. Deterioration in membran strength is also a major problem, but a pilot plant has bee successfully operated to yield 15,000 gallons of water p day, or about 60 percent of the water treated.

The electric membrane process is particularly feasib for the economic treatment of brackish waters where th initial dissolved salt content is less than 4000ppm. Howeve waters carrying calcium sulphate or carbonate in large pe centages of the total mineral content are more difficult treat by this process than those containing mainly sodiu salts.

The limiting factor in the use of this technique has bee the membranes, i.e., obtaining the optimum relationship b tween such propertes as selectivity, permeability to solven electrical conductivity, and mechanical strength. Generall however, it has been demonstrated, 1) that demineraliza tion processes utilizing ionic selective membranes appea promising and, 2) that improved membranes are needed.

Research on osmotic processes for demineralization h shown that the reverse-osmosis technique has considerab promise. Although flow rates are generally low, very larg

ffective areas of osmotic membranes can be stacked in a elatively small volume and, with appropriate equipment, a easonable volume of demineralized water may be produced er unit of time. However, as seen in the electric membrane rocess, durability of the membranes is a salient problem.

The application of freezing processes to demineralization resents many attractive features, among them a lessened endency towards scaling and corrosion because of the lower emperatures involved, and the potential economy due to the ower value of the heat of fusion as against the heat of aporization. Suitably designed refrigeration and heat-ransfer equipment should greatly diminish the overall nergy requirement per unit of fresh water produced. The najor problem with this technique lies in separating the rystallite ice from the brine mother liquor. Much occlusion f brine occurs between the interstices of the crystallite orms and satisfactory methods of separation have not yet een developed. The most effective method of separation is pparently compression; straining and centrifuging are of esser value. The overall cost of operation of freezing and ompression separation is relatively high, however, and nuch improvement of the process is necessary to reduce osts to economic levels.

one Refining a Possibility

Theoretically, a single freezing cycle should produce otable water from brine, but as many as three or more ycles have been required to attain this end. Thus, zone re-ning processes which make possible minimization of en-rapment and absorption justify consideration for adapta-on to the desalination of sea waters. Usually in zone re-ning metals, separation is achieved by melting a short ortion at one end of a long ingot of uniform cross-section. he molten zone is then caused to traverse the length of the ngot, with melting at the zone front and freezing at the one rear taking place at equal rates. Concentration of im-urities at the end of the ingot depends upon the differential olubility of an impurity between the liquid and solid phases f the metal being purified. Not only has this process been nployed widely in the purification of high-melting point etals but also in the purification of inorganic and inter-etallic compounds, as well as to some low-melting point ystems. Zone refining, or an adaptation of it utilizing a rozen zone rather than a molten zone, would therefore eem a promising process for study as a method of convert-ng saline waters. The efficiency of such a technique can be djudged by its current use in the preparation of heavy ater.

The value of solvent extraction techniques for the eco-omic desalination of sea water depends largely upon ob-aining the most appropriate solvent for the purpose and etermining an inexpensive method for recovering small uantities of residual solvent from the raffinate and water roduct.

Essentially, the extracting liquid must absorb large uantities of water without losing its identity and, at the me time, be nearly insoluble in water. The extraction of esh water from the brine and its regeneration in a potable orm must be effected by only moderate change in solvent emperature. Several solvents applicable to this use are nown, and of these attention has been centered mainly up-n substituted amines and glycol-ethers, the latter being preferred because of their greater chemical inertness to sea water. Investigations to date have indicated that obtaining fresh water from sea water by solvent extraction is technically possible. Low cost of producing water by this process depends upon obtaining a superior solvent and a satisfactory method of solvent recovery. It now appears that both of these requirements may be realized. END

TABLE 1

Dissolved Constituents	Brackish Water	Sea Water	Potable Water
		(parts per million)	
Total Solids	149	3.5×10^4	400
Hardness ($CaCO_3$)	140	—	<120
SiO_2	1.2	1.1	—
HCO_3	115	105	—
SO_4^{11}	29	2.3×10^3	<250
Cl^{1}	26	$16.6 \times 10_3$	<250
Fe	0.33	0.05	<0.3
Pb	—	0.004	<0.1
Cu	—	0.008	<3.0
Mg	—	1.1×10^3	<125
Na	—	9.1×10^3	—

TABLE 2

	billion gal.
Total "run-off" water usage per day:	180
Irrigation	95
Industrial	
Cooling and heating	25
Process	25
Sanitation and Waste	20
Municipal	
Services	1.5
Consumption	2.5
Sanitation and Sewage	8.0
Rural	3.0

prototypes

"Slow-Scan" TV

Channel width is a precious commodity in today's communications systems. Stephan K. Altes has developed a "slow-scan" TV system whose signal can run over ordinary telephone lines. Because pictures can only be transmitted at the rate of one every four seconds, the system is not suitable for broadcast TV, but is perfectly satisfactory for many jobs such as verifying check signatures in banks, as shown above.

Developer: Electronics Laboratory, General Electric Co., Syracuse, N. Y.

Navigational Trainer

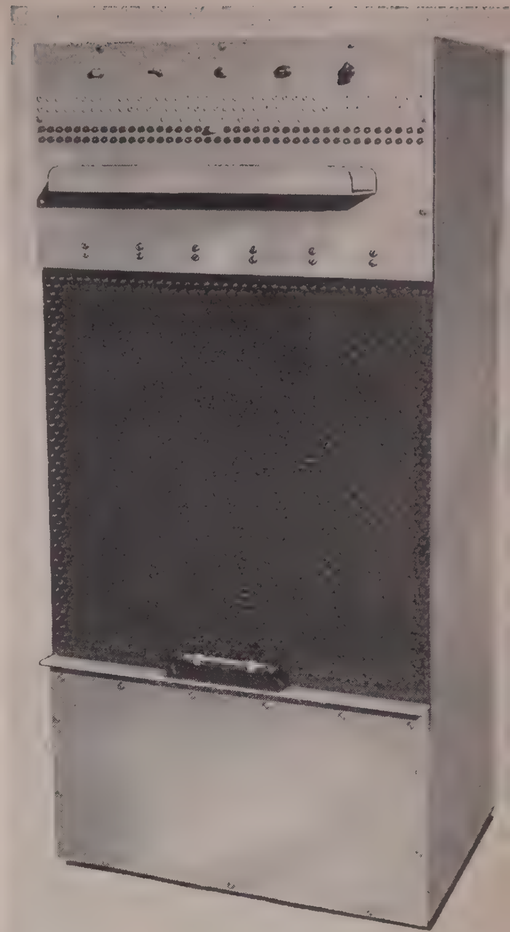
Thirteen navigators can be trained at once in booths like this in new navigational flight simulator. The simulator can save the sands of hours of flying time. From the operator's console, diff ent and rarely encountered weather conditions can be develop for each pupil. Speeds up to 1500 knots can be set in.

Developer: Reflectone Corp., Stamford, Conn.

Bingo!

Truly random numbers are generated by this developmental Stochastic Generator. This computer accessory eliminates the need for drawing numbers from a bowl and is capable of generating rectilinear distributions as well.

Developer: Loyola Laboratories, Box 45074, Airport Sta., Los Angeles 45, Calif.
For more data: circle 30 on p. 48.



ited Shelf Life

olid-electrolyte battery has a practically unlimited shelf life. Consisting of 200 cells, it 's currents in the micro-microamp range at 95v. Although already in pilot plant produc- urther development work is in progress. Primary materials are silver, silver iodide and ium pentoxide. In service the battery can withstand temperatures ranging from —70° to °F.

oper: National Carbon Co., 60 E. 42 St., New York 17, N. Y.
ore information: circle 31 on p. 48.

king Through His Hat

ansistorized two-way radio has been built into this soldier's helmet. To prevent enemy intercep- , the experimental device is preset for short range conversations between squad members, but ge can be quickly increased to one mile. The f-m radio could also be used by policemen and truction workers.

eloper: Signal Corps Laboratories, Fort Monmouth, N. J.

Research Administration

MERRITT A. WILLIAMSON

To continue our discussion of selling, let us consider the matter of selling to subordinates. Twenty years ago this subject would have made little sense to the majority of managers. After all, weren't subordinates hired and paid to carry out the orders of their superiors? What could be simpler? Professor F. J. Roethlisberger in an article appearing in the *Harvard Business School Bulletin* fixes 1936 as the year when the old way of thinking began to die out and a new, more exciting, more adventurous, and more friendly one was born. The new, more scientific orientation, he points out, was based not on a need to justify or defend, to praise or blame, but rather on a desire to learn what takes place when people work together. As time went on it was discovered that efficiency and productivity were related to the worker's job satisfaction, his individuality, and his need for learning and growth.

Selling to subordinates is a *sine qua non* of the manager. It rests squarely on recognition of the individual and makes extreme demands on the versatility and flexibility of the manager. Many engineers and scientists are horrified to see someone using tools improperly, or to see delicate instruments mishandled. Selection of the right size and style of wrench may prevent damage not only to the tool but to the equipment and the worker as well. Yet how many engineers and scientists who are "thing-oriented" get the same acute feeling of discomfort when they see others mishandle a personnel problem?

How many times have you seen a supervisor give instructions in such a manner that you know resentment will arise? In earlier days, skill in this direction probably carried little premium, but now if an employee is not satisfied with the way his supervisor handles him, he can easily find more congenial surroundings. This is particularly true in the technological and scientific areas. When the techniques of selling subordinates are mastered by our managers and administrators, we will find our efficiency, our output, and yes, our enjoyment of an organization increasing exponentially. This is one of the great fields for research in the future. No manager can afford to neglect it. It also has the by-product of insuring that the manager does the job of management and not the jobs belonging to his subordinates.

No Uniformity

The key to successful selling to subordinates lies in the recognition of the individual. Uniform techniques, when applied to people, will never maximize output. The ch lenge of research and development management is to ta a group of highly individual and creative people wh temperaments range from phlegmatic to erratic, wh abilities vary from average to exceptional and whose kno edge may be profound within narrow areas or superfic over large regions; to take people with all their prejudi and preconceptions, their different ideals, goals and phil ophies, and through organization and inspiration create environment in which each one may obtain gratificati Each one must be personally productive while keepi the organization as a whole moving forward in the direct of company interest. This is no small challenge!

Unless the manager has a broad point of view and tolerant of other viewpoints and operating methods, will select subordinates who conform to his own patt of supervision. He may build a good working team. if he drops out of the picture for any reason, the te stands a chance of floundering or complicating life any successor who uses different supervisory techniqu

Basic Motivations

The problem of selling to subordinates can be sim stated, but its execution is not so easy. The manager m study his people, find out what motivates them, and th appeal to those motives. What are the basic motivatio W. I. Thomas once listed four basic wishes or desires wh he believed to be present in all people regardless of th cultural environment:

- The desire for new experience
- The desire for security
- The desire for response
- The desire for recognition

Students of social psychology have debated these roun and many have composed other classifications. Let us, ho ever, take these four and see how they can be applied to & D personnel. We are dealing with a class of people above average intelligence, people who have been exposed the rigors of formal scholastic training, people who re and think. We are dealing with developed intellects. T does not mean that we are always dealing with people emotional maturity, well integrated personalities, or peo with good "judgement".

The desire for new experience. Can we express what

want done in such a way that it has elements of novelty in it? Can we appeal to the love of experimentation when we outline the direction we want the work to take? Can we show that this is not routine and that new experiences may develop from this which can well tax the greatest abilities? We should do this rather than just sell the job, which, of itself, may not be too inspiring. We should always sell the effect or the result and not the job to be carried out. As Elmer Wheeler says, "Don't sell the steak —sell the sizzle" . . . "Don't make 'em drink—make 'em thirsty"! Your own personal interest and enthusiasm are important factors. Anything you give to others for action stands a better chance of success if you yourself believe in it and you let your subordinates know that you are behind it. Alert engineers and creative scientists are always seeking new experiences. This is a powerful motive to bear in mind while selling a new project or a new approach.

The desire for security. We hear and read a lot about security these days. This is an old need stemming from the time when ostracism meant death. In most discussions financial or job security is what is considered. For engineers and scientists however, the desire is rather for security of reputation and the security provided by the rigor of their physical constructs of the universe. Many are certainly unwilling to take too deep a plunge into the realm of hypothesis. Their security rests on their reputations and they do not want to be associated with too "wild" a program. How much this scientific conservatism, this unwillingness to examine anything too radical, slows up the wheels of progress is impossible to gage. Where it exists, however, it is probably due more to the underlying demand for security rather than it is to a closed mind. When a program or a course of action is "sold", it should be made clear that the professional security of the worker is not jeopardized. Public opinion and the opinion of colleagues are great limitors of men's thoughts. This may be desirable, but it may act as a deterrent to great forward leaps in understanding. It takes a certain stubborness of character to prevail against the security of orthodox thought. This is probably a very subconscious desire, but any selling should subtly cover this point; otherwise, it may be the source of an uneasiness incapable of verbalization or recognition.

The desire for response. If we expect our personnel to keep on making contributions we must respond to their efforts. Adopting a suggestion is a response provided that the suggestor knows of its adoption. Rejecting an idea is a response which can best be handled by a discussion of the reasons for such action. But the complete apathy with which many ideas, suggestions, and inventions are received can only serve to deter any further contributions. The Technical Memorandum concluding with recommendations for further action that is buried in the file, the short note that suggests a change in procedure and is never acknowledged are two excellent examples of how to discourage receptivity in subordinates. Why should they always buy your ideas when you repeatedly reject theirs with no explanation?

The desire for recognition. This is widely known and appreciated. It refers to the right to publish papers and to develop a reputation. Our challenge as managers is to find out the particular areas of competence of each of our subordinates and then to make certain that at least within our own organization all of our employees recognize the outstanding talent. This will do much to insure the reception of ideas from supervision. There are a number of techniques which might be used, but techniques have to be matched to personalities. Perhaps you have some particular knacks which could be passed along to other readers. We shall discuss specific techniques in a later column.

The Case of the Unenthusiastic Manager

The case for this month is a simple, but, I suspect, a controversial one. Mr. Fall is manager of an R & D department comprised of about 20 technical people. He has three section heads who report directly to him. Mr. Goff, the Director of Research, has discussed with him an organizational change which he wishes to effect. Fall does not think the change is desirable and has given his reasons, one of which is the fact that his department personnel do not think it is desirable either. Mr. Goff, after unsuccessfully trying to convince Fall, told him that the change *must* be put into effect. How does Fall proceed? Does he pass the directive along with comments that it is not his idea? Does he pass it along without comment? What does he say if asked how he feels about it? Does he pass it along as though he were enthusiastic about the idea and give all the reasons which Goff has given him in support of the change? How should instructions be relayed to the department in these circumstances? Can you state any guiding principles?

Discussion of the Servocomp Case

You will recall that this case, (presented in the April and May issues) dealt with a company whose research and engineering departments were being reorganized. In the first case, the president instructed the two department heads to divide up the work between themselves according to the titles of their departments, but nothing was accomplished. The second case dealt with the events leading up to the reorganization from the point of view of the workers in the departments. My last column gives a more complete review as well as the questions asked.

D. B. Keyes of 480 Park Ave., New York City, writes that it seems to him "that Servocomp's top technical man has made the fundamental mistake of not making a truly objective study of his organization. If he had done so, all of the R & D top men would have had a clear idea of the major changes before they were put into effect." Keyes points out that the case sample in "The Management Consultant" by Samuel D. Hobbs, (RESEARCH & ENGINEERING, *May, 1956, p. 31*) clearly indicates how an outside group would handle such matters.

E. J. Caron, manager of Electronics Engineering Dept., Radio Condenser Co., Camden, N. Y., states that the entire problem revolves about lack of proper communication. He cites the following deficiencies: "1. The president is not well informed about the fields of endeavor of the two departments. 2. The Vice President and the two department heads should have met and discussed plans at regular intervals with the V.P. acting as referee until the plan had been set up. 3. All parties of the supervisory level should have been informed on the same day. 4. The two department heads did not communicate properly to insure coordination." He takes the president to task for dealing directly with the department heads, presumably in the absence of the V.P. who may well have been confused as to what the president was trying to accomplish.

Howard R. Moore of the Naval Air Development Center

at Johnsville, Pa., points out that the "growing apprehension of personnel in both departments bears elegant testimony to the failure of secrecy in withholding the desired information from the main body of technical workers. Strife between the department heads would have been avoided if the Engineering Head had openly acknowledged the pending relinquishment of development functions which unwittingly had been assumed by his department in the rapid growth of electromechanical projects. This executive should publicize the desirability of this change in improving the effectiveness of his department in engineering more saleable products and providing better engineering services for the customers." In his opinion, the V. P. has the obligation to issue a final directive authorizing the reallocation of duties giving reasons why the reorganization is good for the company and the personnel concerned.

O. T. Simpson of the Philco Corporation, Philadelphia, comments as follows: "Sometimes reorganization of technical groups is brought about by specific needs (either the changing requirements on the job or changing personnel) while at other times it comes only on the whims of the director or supervisor. This case of the Servocomp reorganization is very clearcut in that it is satisfying a real need due to new circumstances. It would therefore seem entirely possible that the officers and supervisors could be wholly honest not only with the section managers, but also with all the employees.

"Since the emphasis is being shifted from Engineering to Research, it would seem practical to make advancements in position for personnel in both departments, rather than favoring those in the Research Department. As such, therefore, no one need feel slighted. In the case of the section head who is being eased out, if this were the first time any deficiency in his work had been noted, it would seem a drastic step to take without having made any preliminary approaches to the problem. The mere fact of reorganization does not excuse the proper dealing with inefficiency or other shortcomings in employees."

Robert Y. Wing of the Engineering Div., Stanford Research Institute, Menlo Park, Calif., says it is a fundamental principle that a subordinate should hear directly from his boss about 1) any possible job reassignment and 2) any notification of pay raises. These two situations cannot be handled by delegation or left to rumor. He further comments: "The most severe mistake made by the Director was in not informing the Division Head most affected of his new assignment. The remaining Division Heads would have been advised of the plans, either individually or in a group, their suggestions asked for and evaluated, and asked to keep the reorganization plans confidential. Then, when the President's decision was made, communication downward could be carried out making sure that each level in the organization heard officially at the same time. Sidewise communication was most detrimental.

"The Division Heads are obliged to inform the Director of the upsetting factors in prolonging the official announcement. The day by day time-table as presented in the case material would be a good way to present the story to the Director. Communicating upward the bad effects on morale of the delayed reorganization announcement is most important in avoiding a similar mistake in the future."

(*Please address replies to Dr. Merritt A. Williamson,* RESEARCH & ENGINEERING, 77 *South Street, Stamford, Conn. Your name will be withheld on request.*)

R/E views the books

Mathematical Theory of Elasticity

BY I. S. SOKOLNIKOFF

Reviewed by H. D. Conway, Professor of Engineering Mechanics, Cornell University.

This well-known text first appeared in 1946, and is based on a course of lectures given by the author to students attending the Graduate School of Brown University. The arrival of the second edition will be greeted with enthusiasm.

Unlike many second editions, this is most definitely not a reprint of the first with a few relatively minor additions and corrections. On the contrary, this book has been extensively rewritten and brought up-to-date. To give an example, the material of the last three chapters entitled, "Two-Dimensional Elastostatic Problems", "Three-Dimensional Problems", and (most important) "Variational Methods", respectively, occupies 216 pages and is essentially new.

Along with the better known solutions of the field equations, newer and more general methods of solution are included, many of the latter having been developed by the Russian schools influenced to a great extent by the celebrated elastician N. I. Muskhelishvili. Indeed, very many of the references in the text are to works published in the Russian language which, unfortunately, makes them of limited value to all but a select few.

As in the first edition and as perhaps indicated by the title, this is not a book for the beginner in elasticity, nor is it a text for the reader with limited mathematical equipment at his disposal. For those already familiar with the standard "engineering" texts in elasticity and having sound mathematical training, this book is heartily recommended.

McGraw-Hill Book Co. Inc., 465 pages, $9.50.

Theory of Games as a Tool for the Moral Philosopher

BY R. B. BRAITHWAITE

Reviewed by Frederick L. Zarnfaller, International Business Machines Corp.

Although concise and descriptively accurate, the title Professor Braithwaite has chosen for his inaugural lecture is perhaps unfortunate. For mathematicians, philosophers, logicians—a relatively small group—the title per se may be inviting. For the larger group of those involved in more mundane pursuits, whose time is adjudged at such a premium as to require (questionably) effective limitation of their literary explorations, the title may have too esoteric a ring for attraction. Yet it is precisely for this group that it has value.

Professor Braithwaite has, with remarkable lucidity of style, made an application of mathematical discipline to what superficially appears to be a non-mathematical situation or problem. The lecture is fast, good, suggestive reading. For the imaginative individual involved in fields far removed from casuistry and mathematics, Braithwaite's delightful description of his solution of the problem confronting his interfering trumpet and piano players should be sufficiently stimulating to suggest that in the theory of games, there are techniques and results of potentially vast import to the reader's own field, whether it is economics, some phase of judicial science, the field rather enigmatically referred to as labor relations, or a host of others.

As in all short pioneering works, drastic assumptions must be made. Braithwaite considers in detail only the case of two individuals, Mathew (M) and Luke (L), whose activities throw them into an unavoidable and conflicting situation, in which each has a choice of two alternative courses of action. He assumes that M or L (or both) propositions him to determine the best solution to their dilemma and also that either (or both) has provided him with sufficient information to measure weakly their preferences as to courses of action. He does not require that L be able to assert definite preferences for the various outcomes (four in number) and similarly for M.

The author then establishes three categories into which the problem may fall: (1) the wholly competitive situation (zero sum—two person game); (2) the wholly non-competitive situation; and (3) the neither wholly competitive nor wholly non-competitive situation (non-zero sum two person game). Problems falling into the first two categories are easily solved, having been well described by current theory of games techniques. The third category, which is by far the most interesting, represents almost virgin territory and it is here that Braithwaite introduces some novelties. He asserts that the logic of the (2x2, non-zero sum) situation at hand is isomorphic to the geometry of the parabola determined by the pure strategy lines and he divides the problem into two parts: (1) a wholly competitive portion, in which M and L compete for issorhopes ("lines" of constant relative advantage which he claims to be parallel to the axis of the parabola determined by the pure strategy lines); and (2) a wholly non-competitive collaboration between M and L, to share a cooperator's surplus. (This sharing, indeed the entire development, depends upon the concept of fair play or justice. Any solution must be such as to distribute fairly the fruits of the situation. Any gain through cooperation must be justly divided in accordance with the intrinsic logic and natural advantages of the situation.) Previous results by other workers in the field establish only a lower bound on the solution to the problem. The second step in Braithwaite's approach allows the realization of a much more satisfactory solution to both parties concerned than is represented by this lower bound.

Thus in the first step M and L agree to the prudential issorhope (i.e., the line on which the best solution must lie). The second or collaboration part constitutes essentially climbing this issorhope to the best solution for all concerned. It is interesting to note that the prudential issorhope allows an inter-evaluation of the hitherto uncorrelated and distinct individual evaluations given the action outcomes by M and L respectively.

There are some general criticisms which this inaugural lecture admits. Although on the whole Braithwaite's style is extremely lucid, there are points where the logical presentation of the argument seems inverted (e.g. pp. 9-11 on the assignment of a weak measure to the outcomes). Though few in number, they are relatively annoying and mar an otherwise excellent exposition. The restriction of the problem considered to two alternative courses of action per individual is not serious, since, as he indicates in the appendices, the generalization to n outcomes is rather straightforward though considerably laborious. However the assumption of a two person game is a serious simplification—almost an oversimplification. For, while there are many problems which may reduce to such, there are many more involving more than two persons. The mathematical complications introduced by the real possibility of cabals and cartels are not to be minimized.

The assumption that the situation must be repetitive and simultaneously independent of past history is a considerable limitation. Many problems arise which certainly do not possess the repetitive character implied and required by Braithwaite. However solutions of such may well be achieved through the inspection of "finite point sets" superimposed on continuous or repetitive strategy diagrams. Independence is not as easily sidestepped. In the particu-

lar problem Braithwaite considers, L's evaluations for example may well be time functions. As such they may or may not be periodic. If they are, the problem may admit a solution through the use of appropriate expectations or averages of the evaluation functions. If they are not, it does not appear that Braithwaite's approach admits of a reasonable generalization able to deal with such functions.

As to the general power of this approach to casuistry, there appears to be a significant situation which Braithwaite either does not recognize or wishes to avoid completely. This is characterized by a dual system of evaluations or preferences. It may well be that Braithwaite's trumpeter (M) can express a set of preferences based on the pleasure derived from annoying Luke. For M, there are then two distinct sets of values and it is not apparent that there exists a reasonable method of extracting a single (weighted) set of preferences which is a requisite of Braithwaite's approach. The possibility of the existence of such dualities should be evident upon a little reflection and indeed their existence constitutes the source of many of the social woes besetting our society today.

Braithwaite's method depends basically on the concept of fair play (fairness, equal distribution), i.e., the parties to the conflict wish a fair solution, one in which the intrinsic logic and advantages are accurately reflected. One can not take exception to such an assumption for exploration into the field of ethics and moral philosophy. Every discipline uses idealized models, often to good advantage. On the other hand, observation of the machinations of mankind justifiably admits reasonable doubt as to whether one could gain acceptance of such an assumption in a genuine situation.

Braithwaite's lecture is well planned and well executed. Although there are isolated instances in which the order of exposition seems logically inverted, these are so few as to be negligible. Generally his style is lucid and concise. For such a work, it has the amazing quality of yielding knowledge proportional to the effort invested in its consideration. For the hurried reader, the main body of the work presents the essentials of the approach supported by heuristic but enlightening goemetrical argument. For those prepared, the appendices contain a succinct outline of the general case developed analytically. In brief, "Theory of Games as a Tool for the Moral Philosopher" is good reading. Although it will be of interest to the specialist, it should definitely be of interest and value to a much larger section of the public. By its subject matter, scope and clarity, Braithwaite's compact tome may well provide the stimulus for creative exploration for those imaginative individuals, whose occupations, though hardly related to mathematics or ethical philosophy, involve dealing with situations of conflict and competition.
Cambridge University Press, $1.25.

Reference Texts

Bibliography of Research on Deuterium an Tritium Compounds 1945 to 1952, Circular 562 85 pages, $0.50. (Order from Governmen Printing Office, Washington, D. C.)

Compiled in this circular are 2482 researc references covering the properties of deute rium and tritium compounds. It is divide into three sections: a bibliography and au thor index, subject index, and deuteriun and tritium compound indexes.

Regulation of Radiation Exposure by Legisla tive Means, NBS Handbook 61, 60 pages, $0.2 (Order from Government Printing Offic Washington, D. C.)

This handbook presents the problem o radiation in relation to its possible contr by state or municipal authorities. Thi topic is very new to all but two or thre States. The material it contains will pr vide a convenient and suitable basis fo the development of uniform radiation-con trol regulations.

Mass Spectrometer Researches, by Dr. G. Barnard, Dept. of Scientific & Industrial Re search, Charles House, 5-11 Regent St., Lon don S. W. 1. England. $0.63 in U. S.

This describes special features of an ex perimental sector-field mass spectromete constructed at the National Physical Lab ratory, England, and some experiment researches with this instrument. Variou ion source designs of the electron bombar ment type were examined to get a bette understanding of the role of the magnet field in the source region.

Reactor Shielding Design Manual, edited b Theodore Rockwell III, U.S. Atomic Energ Commission. McGraw-Hill Book Co., Ne York, N.Y., 488 pages, $7.50.

A new manual on how to design practic reactor shields, largely based on metho and data used for naval reactors and th Pressurized Water Reactor. In general, th information is in the order in which designer would use it to develop a shiel design. Contents: basic processes; dete mining allowable radiation levels; shiel ing the reactor core and the cooling sy tem; shield engineering, the effect irregularities in the shield, and the effe of geometry on radiation source; influen of plant layout, structure, and maintenan upon design.

Bibliography of Solid Adsorbents, 1943 1935, by Victor R. Deitz. NBS Circular 56 1528 pages, $8.75. Government Printing Offic Washington 25, D. C.

A complete author index and a very co plete subject index are features of th survey. The effects of adsorbents on pa ticular gases, liquids or solutions are particular interest to petroleum, biochem cal, mining and metallurgical industri and to those interested in catalysis.

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

Bibliography on Shells

Because of the geometric resemblance of the pressure hulls of submarines to thin elastic shells, the analysis of submarine strength has leaned heavily on the technical literature of shell theory. By 1950 this literature had grown enormously, and so the new Navy bibliography, current through December 1953, has been prepared for use by designers of submarines, mines, torpedoes, rockets, and similar structures.
BIBLIOGRAPHY ON SHELLS AND SHELL-LIKE STRUCTURES, *PB 111964, 74 pages, $2.00*

Fracture of Brittle Ceramics

Part I of a two-part report of Air Force-sponsored research on the fracture of brittle ceramic materials investigates the factors influencing the fracture of brittle ceramic materials. Emphasis is on the effects of size and stress state. Also studied are the effects of strain rate and temperature.

Part II sets forth the principles for the selection, evaluation and design of brittle materials from a statistical and probability viewpoint.
BEHAVIOR OF BRITTLE-STATE MATERIALS, *PB 111987 Part I, 153 pages, $4.00; PB 121002 Part II, 161 pages, $4.25*

Fluorescent Paints

Targets colored with orange and scarlet fluorescent paints have been found to be outstandingly detectable in air-to-sea sightings, according to a Naval report which resulted from research to determine the relative detectability at sea of colors in the red through yellow range. Air-to-sea sightings were made from aircraft flying at 700 feet altitude in fair weather.
FIELD STUDY OF DETECTABILITY OF COLORED TARGETS AT SEA, *PB 121016, 37 pages, $1.25*

Self-Diffusion Studies

A report of research into the mechanism of atom movements in crystalline solids, particularly metals, describes a unified phenomenological theory of melting and diffusion in both liquid and crystalline solids resulting from a relationship found to exist between the activation energy for self-diffusion and the latent heat of fusion. The relationship is interpreted in terms of the crystallite theory of the structure of liquids.
SELF-DIFFUSION IN CRYSTALLINE SOLIDS AND IN LIQUIDS. PB 121066, 72 pages, $2.00.

Transistors and Rectifiers

Two Industrial Preparedness Studies. In the first Study, the purpose was to develop a point-contact switching transistor and a general purpose junction transistor. Necessary manufacturing equipment and facilities were to be designed, built and operated in a pilot run. Includes review of the engineering development work and summarizes the design features of these two transistors.
INDUSTRIAL PREPAREDNESS STUDY: TRANSISTORS AND TRANSISTOR MANUFACTURING EQUIPMENT, Vol. 1, PB 111822, 200 pages, $5.00. Vol. 2, PB 111820, 42 pages, $1.25.

The second Study reports process improvements, including development of soldering the silicon junction wafer directly to the base and further development on welding the lead at the final sealing operation, have increased the yield and improved the mechanical and electrical characteristics of silicon power rectifiers manufactured according to procedures described in this report.
INDUSTRIAL PREPAREDNESS STUDY: SILICON POWER RECTIFIERS, PB 111819, 38 pages, $1.00.

Analog-Computer Simulators

A basic reference book covering rudiments of operation and maintenance common to all analog-computer simulators has been prepared by the Navy. The text is intended to bridge the gap between the better-understood synthetic trainer and increasingly complex modern trainers. Part I covers general principles of analog computers. Part II describes individual components used in servo-mechanism and computer systems, and procedures in general maintenance.
THE PRINCIPLES OF COMPUTER SIMULATION, PB 121200, 158 pages, $3.00.

Storage Battery Analyzer

A new storage battery analyzer featuring simplicity and accuracy of control, a wide scope of variables measured, and a complete, continuous record, has been developed by Naval Research Laboratory. The analyzer was developed in an attempt to meet the need for a more complete analysis of fully assembled cells under operating conditions. The instrumentation is simple to understand and use, and can, for the most part, be built from commercially available parts at a reasonable cost.
BATTERY ANALYZER FOR USE IN STORAGE BATTERY UNITS, PB 111932, 20 pages, $0.50.

INDEX TO ADVERTISERS

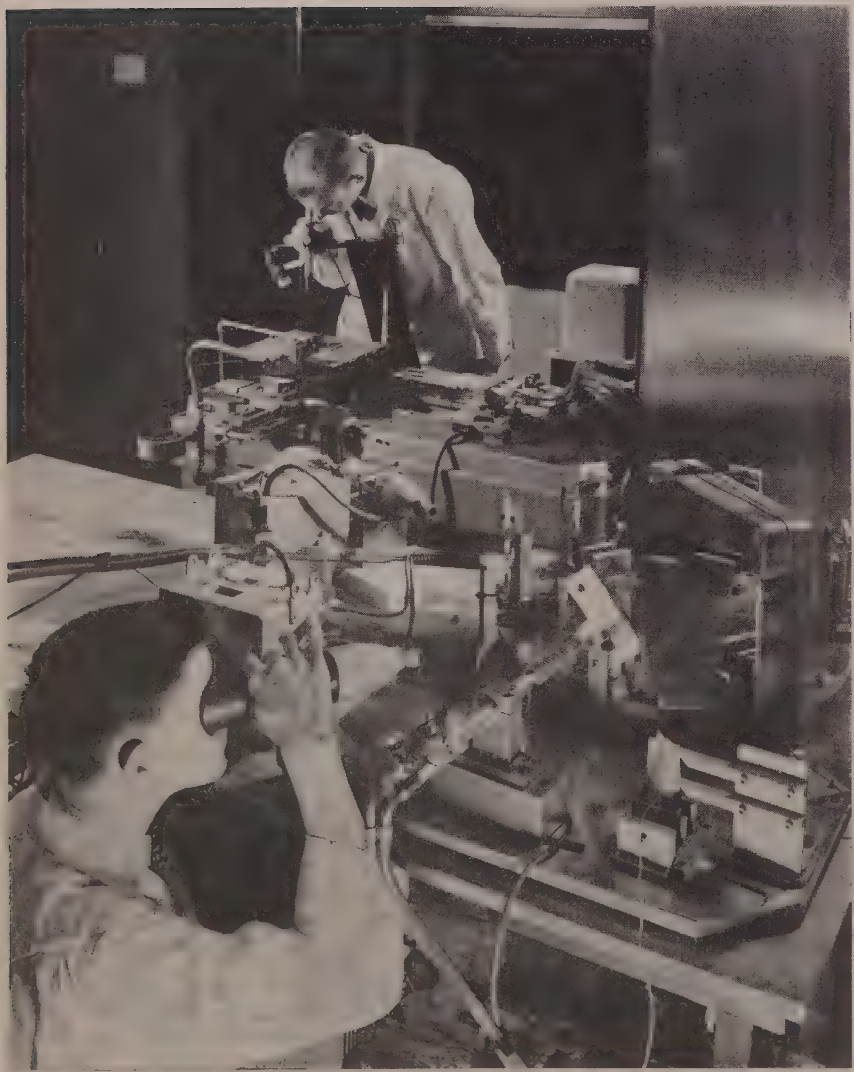
Measures Gamma Radiation

Sodium iodide is the sensitive element in this Scintillation Well Counter (Model DS-3A). A preamplifier circuit permits its use with gamma-ray spectrometer systems. The counting geometry provided by the "well" permits rapid measurements and enables the user to obtain maximum statistical accuracy with minimum amounts of radioactivity.

Developer: Nuclear-Chicago, 229 Erie St., Chicago 10, Ill.

For more data: circle 38

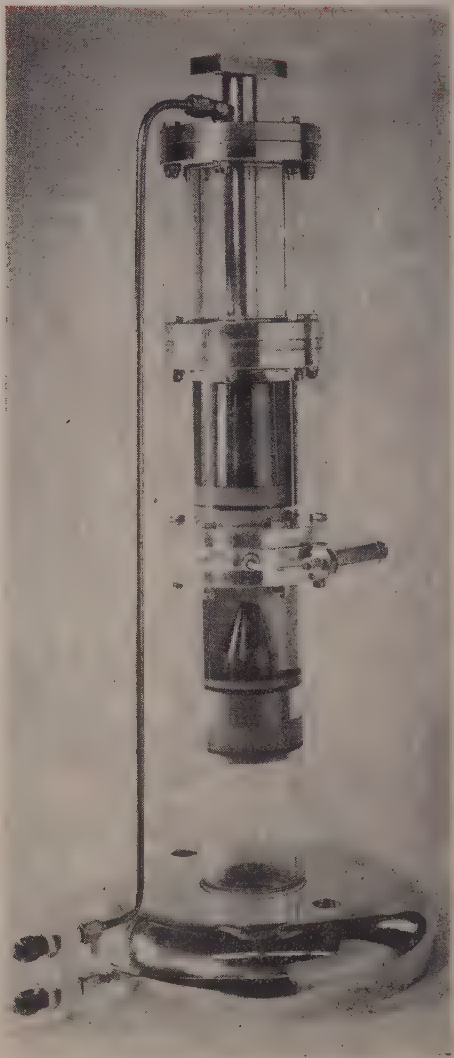
YARDSTICKS



Engineers Look "Inside" Jet Engine

The intense heat and vibration which turbine blades endure in jet aircraft engines are duplicated with this test apparatus. In foreground the blades rotate through hot blasts of acetylene flames to see how they stood up under "thermal shock". In back the blades are subjected to high frequency vibration while red hot so engineers can find out whether they develop "fatigue" cracks under conditions experienced in actual use.

Developer: General Motors Research Staff Laboratory



Shocking!

High shocks for dynamic environmental testing are produced by this "Hyge Actuator". A single unit only 26" high is capable of a 12,000 lb. thrust. Built of modular components, this hydraulic device was designed by Convair.

Manufacturer: Rochester Div. of Consolidated Electrodynamics Corporation

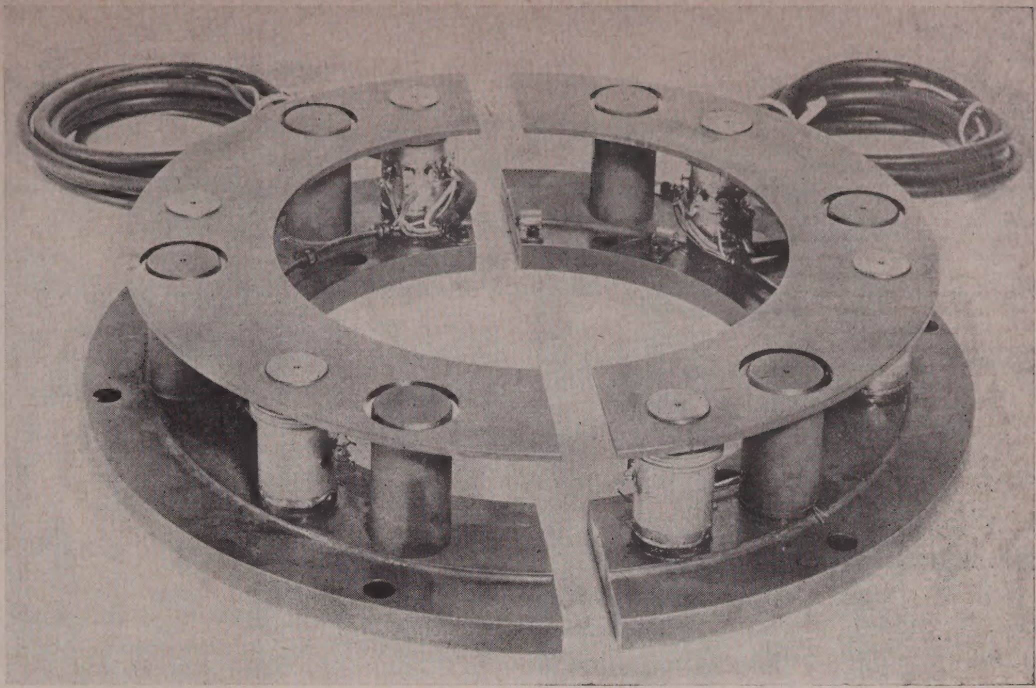
For more data: circle 40

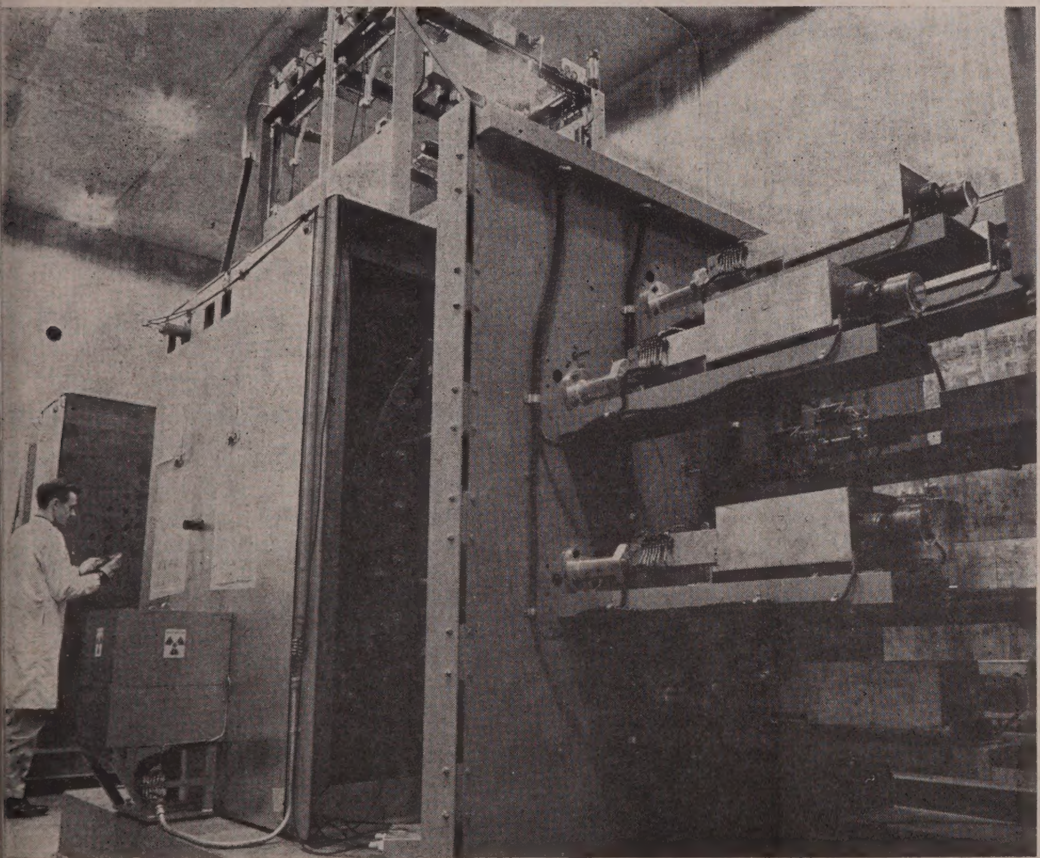
Thrust Supervision

Increased size, temperatures, pressures and complexity of steam turbines has made necessary the continuous supervision of thrust loads on the shafts. Resistance-wire strain gages in a special element installed as part of the Kingsbury bearing, measure thrusts.

Developer: Electronics and Instrumentation Div., Baldwin-Lima-Hamilton Corp., 806 Massachusetts Ave., Cambridge 39, Mass.

For more data: circle 36 on p. 48.





Test Reactor

Proposed arrangements of atomic fuel in reactor cores are tested in this experimental reactor at the AEC's Hanford plant. The operator builds an experimental arrangement of fuel and graphite moderator in the center, moves the end block snugly against the central section, and measures resulting operating characteristics with recording devices in a shielded room.

Developer: General Electric Co., Schenectady 5, N. Y.

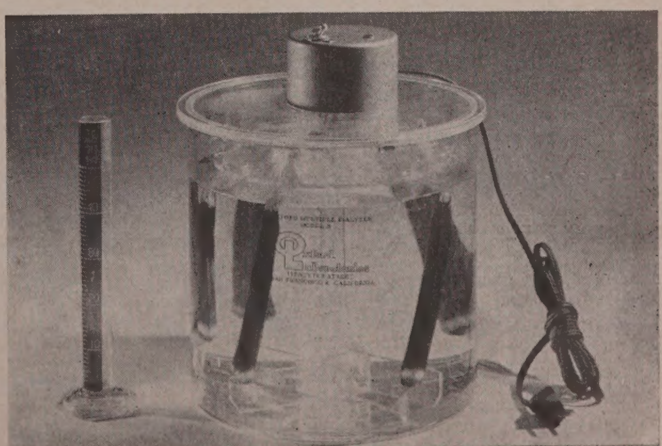
For more data: circle 39

Aid in Polymer Chemistry

As many as 16 separate samples can be treated simultaneously for either equilibrium dialysis or concentration dialysis against a buffer volume of five liters in this Model B Dialyzer.

Developer: Oxford Laboratories, 111 Sutter St., San Francisco 4, Calif.

For more data: circle 37 on p. 48.



Here's a brief review of last month's product and service advertising in RESEARCH & ENGINEERING as a service to our readers.

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designed and engineered to meet the most exacting standards. Over 350 different standard relays from stock.
Potter & Brumfield Inc., Princeton, Ind.

Wide-Band Oscilloscope 102

Type 515 is a small, light weight and versatile unit; its compactness makes it especially suitable for use in the field.
Tektronix Inc., P.O. Box 831, Portland 7, Ore.

Model 21 Spectrophotometer 103

can be used in quality control, in identifying products after reactions, to check customer samples and final material, and for determining molecular structure.
The Perkin-Elmer Corp., Norwalk, Conn.

Synchros 105

Series R900 have new high-temperature stability and high accuracy and corrosion resistance. These components are low in price and available for immediate delivery.
Kearfott Company, Inc., Little Falls, N.J.

Packaged Vacuum 106

systems come ready to work and add flexibility to operations. Particularly useful and specially designed for experimental, pilot plant and production applications.
Kinney Mfg. Div., The New York Air Brake Company, Inc., Boston 30, Mass.

Vacuum-Deposited Coatings 108

are described in 31 quick-reference sheets. Information on reflection, transmission, adherence, hardness, water resistance and other data.
Liberty Mirror Div., Libbey-Owens-Ford Glass Co., Brackenridge, Pa.

Spring Pins 109

are slotted, chamfered and cylindrical, lock securely in place, yet can be drifted out and reused whenever necessary.
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N.J.

High Vacuum Pump 110

with convenient oil drain for industrial use in production of luminous tube lights and television tubes. Also for direct use or in conjunction with diffusion pumps in the exhaustion of large laboratory appliances.
Central Scientific Co., 1734 Irving Park Rd., Chicago 13, Ill.

Lithium Bibliography 112

4th supplement to original work contains 271 abstracts of recent papers. Complete bibliography offered free of charge as a reference work and guide.
Lithium Corporation of America, Inc., Minneapolis 2, Minn.

High-Speed Photography 113

improved by versatile Fastax camera. Speed range of 125 to 16,000 pictures per second and capacity of from 100 to 500 feet. Available in motion picture, oscillographic or combination models.
Wollensak Optical Co., 854 Hudson Ave., Rochester 21, N.Y.

Matched Systems 114

for random vibration testing now available. Electrodynamic Shakers, Random Noise Amplifiers and the Model 188 Console comprise a typical control unit for any of several systems.
The Calidyne Company 120 Cross St., Winchester, Mass.

Tach Generators 115

for accurate speed indication and rate control applications are available in three different frame sizes with maximum rated outputs up to 7000rpm or 100 volts, whichever occurs first.
Barber-Colman Company, 1474 Rock St., Rockford, Ill.

Weapons Systems 116

Experienced designers, developers and producers of ground handling equipment, electronic and electrical test equipment, special tools and mobile training units. Many supporting facilities available.
Northrop Anaheim, 500 E. Orangethorpe Ave., Anaheim, Calif.

Prototype Builders 117

will help you cut your costs, meet your delivery schedules, and free your creative engineers. Will custom build prototypes, run acceptance tests, mass produce electronic equipment, or do whatever is necessary to solve your particular production problems.
Electronic Assembly Company, Inc. 5 Prescott Street, Boston 19, Mass.

Additional Information Form

9-56

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For more information on products or copies of literature described in the Product Portfolio or in advertisements in this issue, circle the appropriate code number below.

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